# EXPLORING SCIENCE

## Six

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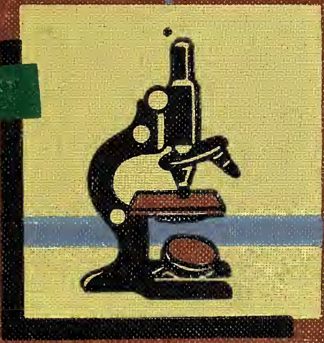

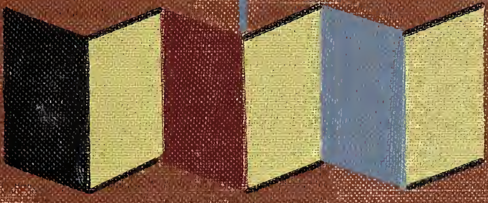

CURRICULUM

*Teachers' Edition*

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# Teachers' Manual for

# EXPLORING SCIENCE

## Six

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# Introduction

## PUTTING SCIENCE IN THE CURRICULUM

"Learn through doing!" "Study things—not ideas!" What excellent precepts for a science programme! For children love to "do" more than they care to sit passively. And they learn best when they are using their senses to study the world about them.

Imagine a cheerful classroom with children taking care of radish seedlings and goldfish; with children keeping records of tadpole growth and weather changes; with children making model boats and cricket cages; with children comparing what books say about robins with their own observations; with children experimenting, arguing about results, and suggesting new ways to prove that there is water in the air.

This is a picture of a science programme that is meant for children. These children are learning more than isolated facts; they are learning to work together, to solve problems, to handle tools, to use books. And they love every moment of it!

Teaching like this is fun. The outcomes are highly satisfying. Children need only the ideas for things to do, a little help in finding materials, and some encouragement. They supply the necessary enthusiasm and energy.

### Some Reasons for Elementary Science

The elementary school is concerned with the growth of the child, —his intellectual, social, emotional, and physical growth. All subject-matter areas have the same general objectives, but they use different methods and content for attaining them. Science, because it deals so much with tangible things, makes several unique contributions.

Much of the programme of the Exploring Science Series involves manipulation, thus developing muscular co-ordination, skill with tools, and familiarity with materials. A number of otherwise outstanding pupils are seriously deficient in manipulative ability, this phase of their education having been neglected. They benefit greatly from opportunities to work with the "things" of the science programme. In contrast, there are a number of retarded readers who find in this phase of science their only opportunities to equal or excel their classmates.

A rich variety of science projects gives all children opportunities for self-expression. Some children best express themselves by making models; some through making friezes, charts, and posters; some by writing science stories, keeping notebooks, and producing science plays; some through collecting and exhibiting.

Science activities encourage pupils to plan, to use ingenuity, and to exercise initiative. When the activities are carried out by small groups, the pupils learn to plan and work together, to share responsibilities, and to assume leadership.

Experiments, field trips, projects, and similar activities stimulate pupils to turn to books for information. By comparing what authorities say with their own observations, the pupils tend to become more critical and they develop habits of open-mindedness and delayed judgment.

Certain phases of the subject matter of science have immediate and important values. Especially important are the learnings that contribute to establishing better health and safety practices. A large share of health and safety education is based upon scientific information. Another area that benefits from science subject matter is conservation education; so closely is conservation allied with science that the two are usually included in the same programme. (Pages 16–18 of this Teachers' Edition discuss the role of science in conservation and health and safety education.)

### How Much Time for Science?

"Can you afford fifteen minutes three times a week for science?" This in answer to teachers who are concerned about the already crowded class curriculum. Successful science programmes have been carried out with as little time as this scheduled for science class work. More time is to be desired, but there need be no sacrifice of other important areas when science is added to the school programme.

An elementary science programme does not demand a great deal of formal class time to keep it progressing satisfactorily. Three or four short periods weekly, or the equivalent, are adequate for pupil motivation, with much of the actual science work being carried on outside class time. Most of the units in the Exploring Science Series require two or three weeks for satisfactory development—for planning, experimenting, and discussing.

Science does not require much class time because children make time for science. They find the work too exciting to be dropped between lessons. They rush to school in the morning to see how their plants and animals have fared through the night. They use much of their free time during the school day for science activities. If permitted they will stay after school to work with science materials. And it is not unusual for a majority of the pupils to repeat at home the experiments they have carried out during their science lessons.

It is possible to make science the core of the entire school programme; many children prefer to make science just that. Many children prefer to talk and write about science for their language work; many prefer to read about science during reading periods; some prefer to base their art work on science subjects. As one teacher put it, "I have learned how to start a science programme. Now show me how to stop it!"

### Planned and Incidental Science

A planned programme ensures steady progress from grade to grade with a minimum of overlapping and repetition. A planned programme ensures breadth of content and balance among the various subject-matter areas of science.

A planned programme gives point and direction to the work of the pupils and keeps their enthusiasm high. It opens up new avenues for exploration. Without planning, science programmes usually become haphazard and are sometimes neglected.

On the other hand, there should be time available for what is called "incidental" science. Pupils should have an opportunity to watch a butterfly that has just emerged or to study a rainbow that has just appeared in the sky. Incidental science deals with the unexpected; it is often responsible for some of the most worth-while outcomes of the science programme.

### Equipment for the Science Programme

Mayonnaise jars, tin cans, paper clips, and soda straws—such are the materials needed for a science programme. There is nothing mysterious about these commonplace materials. When a child does an experiment with a mayonnaise jar he is working with something familiar to him. He can repeat the experiment at home if he wishes. To him, science is the study of familiar things.

A list of materials needed for each unit of the Exploring Science Series is included in the specific suggestions for teaching each unit. A list of all the science materials needed for the year's programme is included at the end of this Teachers' Edition. Children can supply most of the items, such as tin cans and glass jars. Some of these should be stocked in quantities so that there is always a supply on hand.

It is well to make a list of materials that children cannot bring in. This list may include such raw materials as soft pine lumber, wire, nails, and screws. The list should then be discussed with the principal or the supervisor for items that can be supplied by special departments of the school system. Usually only a few items need be purchased separately.

Ideally, materials for an activity programme should be provided in quantity. Instead of a single hand lens, a class of thirty children should have at least fifteen hand lenses. Although this may seem prohibitively expensive it need not be so. Other teachers in the school will probably be able to use the same materials. By providing a central storage space, and by working out a schedule for the use of the materials, the per-pupil cost becomes insignificant.

## HOW TO USE THE BOOKS

Each pair of facing pages in the books of the Exploring Science Series sets the stage for an exciting adventure in science—an experiment, a demonstration, a field trip, a class project. The books are study guides rather than science readers. They present a programme to the pupils and show them how to carry it out.

Some teachers may choose to follow the books page by page, deviating little from the programme as it is presented. Their classes will be meaningful and fun for the pupils.

Other teachers will prefer to modify the programme to fit their special needs. Each book has been planned to permit a high degree of flexibility. How to take advantage of this flexibility and other features are discussed below.

### How the Books Are Organized

Science experiences form the basis for the Exploring Science Series. Emphasis is upon first-hand experience activities supplemented by information given through pictures and reading.

The activities have been selected to provide experiences in all the common areas of science, both physical and biological. This presents a well-rounded programme that appeals to different interests and gives a broad background in science.

The activities are grouped in units centred about such familiar subjects as "Mirrors" and "Sunshine" rather than in units of formalized science. A single unit can, and often does, cut across several conventional subject-matter areas.

The material of a unit is developed in two-page blocks, each of which usually takes up a separate topic. This is a successful pattern often found in how-to-do-it books. It is useful in these science books because pupils can carry out an activity without turning pages.

### The Teachers' Editions

The special Teachers' Editions for the Exploring Science Series contain the material given in the pupils' editions together with detailed suggestions for using this material.

Each unit is introduced with a discussion of the possible outcomes of the unit and a description of the part the unit plays in the entire science programme. Necessary materials are listed. Different methods of developing and enriching the unit are suggested, and valuable background information is provided.

Following these general helps, the material in the unit is considered page by page. Different methods of developing lessons are suggested. There is advice about the use of tools and materials. Possible difficulties are anticipated, and there are many helpful identifications of unlabelled pictures in the text. Answers to questions pupils might ask, follow-up activities, and references are listed. See PREPARING FOR THE UNIT for the best time to begin a unit.

The Teachers' Editions give teachers confidence in their ability to teach science. The Teachers' Editions help teachers to take full advantage of the special features of the books, thus providing a rich and challenging programme.

### Scheduling Science

Most of the units in the Exploring Science Series require two or three weeks for satisfactory development. Children should not be hurried through a science programme. They need time to experiment, to discuss results, to try experiments again. They need time between lessons, too. A pupil who has connected a dry cell to an electric lamp during a science lesson will want to repeat the experience during his free time. He may also wish to repeat the experience at home.

Most of the two-page blocks of a unit serve as the subject for one or more lessons each. One of these blocks may describe an activity that requires a full lesson for completion. Some of the activities may be started in one lesson, as with many experiments with plants, and then finished during a lesson at a later time. Field trips require additional lessons for preparation and for follow-up. Projects usually require several lesson periods.

It is recommended that the minimum time allotment for science be scheduled as lesson periods. Additional time can be used for incidental science or for extending scheduled lesson periods as needed.

There are several ways to provide additional science time without scheduling it at the expense of other subjects. If there is a "science table" at the side of the room, materials may be placed on it for pupils to use in their free time, both in and out of school hours. Individual projects can be started in school and completed at home. There can be correlation with reading, language, art, and social studies. As long as the science programme is interesting, the pupils will find time for it.

### Modifying the Basic Programme

Perhaps spring comes early to your section of the country. Perhaps your community makes much of Fire Prevention Week. The teaching calendar should recognize these and other important events. The flexibility of the Exploring Science Series makes it possible to shift units as desired because the units within a book are independent of each other. A unit involving fire can be moved to early fall, and a unit involving spring can be scheduled for the time when daffodils burst from the ground.

Likewise the material within a unit may be re-organized to take advantage of special conditions. Re-arrangement of the two-page blocks may permit a more suitable activity to open a unit. Additional activities can be inserted as desired. One may also delete some of the activities that do not seem appropriate to the teaching situation.

The class may wish to take up science material that is not included in the programme of the books. This is admirable and the class should be given every encouragement. There are a few cautions that should be observed. The teacher should be sure that the subject is of interest to all pupils and not to just a few of the more aggressive individuals. She should be sure that there are suitable activities to be used in teaching the proposed subject. She should try not to take up material that will be taught by teachers in later grades. If pupils suggest a topic that does not seem suitable for the entire class, the topic may be assigned to certain interested pupils as optional work. Assigning a particular topic to a superior child will frequently re-awaken his interest by confronting him with a real challenge to his ability.

### Beginning a Unit

To start children thinking about magnets put magnets in their hands. To start them thinking about frogs put a frog where they can watch it. That is all there is to starting a new unit.

New materials may be presented in several ways. Sometimes, as with magnets, the materials may be put in the hands of the pupils with little explanation. Sometimes an interesting demonstration can be used; for example, a “race” with burning candles under various-sized jars to see which candle goes out first. Living things, particularly things that move, need only be placed where pupils can watch them.

Special days and special events offer possibilities for introducing new topics. A St. Patrick's Day carnation raises questions that lead to experiments with water movement in plants. Coloured Easter eggs raise questions about dyes that lead to experiments with dyeing cloth.

First-hand experiences make the most interesting and the most challenging approaches to new units. There can be no one best approach to a unit because conditions vary so much, but a little imagination adapts most activities to meet the situation.

### Developing a Unit

The pattern in which the material is presented in the Exploring Science Series is one that has been used successfully, but it is not necessarily the most satisfactory for a particular situation. There can be no one best pattern: much depends upon the interests of the pupils, upon the teaching situation, and upon unpredictable events. A teacher should feel free to modify any unit—re-arranging the topics, adding material, and deleting material.

It is important that there be variety in a unit. Variety keeps interest high and provides for individual differences. Use experiments, field trips, demonstrations, model-making, and science play-writing, to obtain the necessary variety.

Different types of activities make different contributions to a science programme. Experiments and field trips provide the basic first-hand information. Study of books and pictures supplements first-hand information with information that has been gained by other people in different situations. Model-making, play-writing, and similar activities serve to organize information.

These books make use of many different types of activities in the development of the programme. The detailed sections of these Teachers' Editions suggest still more types of activities that can be used to enrich the programme.

### Evaluating Outcomes

As yet, no one has discovered how to measure the truly important outcomes of a science programme. Certainly the facts of science as tested by pencil-and-paper tests are of small consequence. The important outcomes are the attitudes that pupils develop, the skills they gain, and the habits they acquire.

Evaluation of the effectiveness of a science programme is chiefly one of personal judgment. One must depend upon many small but significant signs. One may look for signs of general interest. How many pupils participated in each activity? How many children volunteered for optional activities? How many pupils brought in materials when asked to do so? How many brought in materials without being asked? How many pupils repeated science activities at home? Did pupils talk about their science experiences outside school?

Specific achievements can be used as a measure of success. What experiments were carried out? What field trips were taken? What projects were completed? What books were read?

One may look for signs of pupil growth. How many normally quiet children took active parts in class work? How many passive children took on leadership responsibilities? How many "slow" readers turned to books for information? How many pupils turned out work of improved calibre?

To measure the progress of individuals look for interest, effort, growth, and achievement. Not all children can be judged by the same standards, but if in his own way a pupil has shown evidence of each of the above, one may feel satisfaction with the results.

## SPECIAL TECHNIQUES FOR TEACHING SCIENCE

Most of the teaching techniques used in other subject-matter fields apply equally well to science teaching. But when pupils begin to experiment, to perform demonstrations, to take field trips, and to build models, it is obvious that a teacher must have a knowledge of some additional teaching techniques.

The majority of the activities suggested in the Exploring Science Series are direct experience activities. They are simple and they are clearly described in the textbooks. A teacher should have little difficulty in helping pupils to carry them out, but if difficulties do arise, the detailed assistance given in the Teachers' Editions should quickly clear them up. The real problem that faces a teacher is not that of giving technical assistance with activities: the problem is finding ways to help pupils to gain the most from the experiences.

Science education stresses a number of major goals such as the development of critical thinking and the habit of withholding judgment. The activities which pupils carry out set up the situations that permit these goals to be attained. It is in working toward these major outcomes that many elementary teachers need help.

### The Problem-Solving Approach

What a child learns may be of less value to him than the way he learns it. A curious child can be led to speculate, to experiment, to check conclusions. He can be given practice in defining problems.

He can be given opportunities to exercise his ingenuity. He can be encouraged to develop a critical attitude and an open mind. Such experiences are worth more to him than the bits of information he may pick up.

Elementary science is well-adapted to the problem-solving approach. The materials of science awaken curiosity: "How did this dandelion get in my garden?" "How can I connect this dry cell to an electric bell?" "Why does my dog prick up his ears when he wants to hear better?"

It must be remembered, however, that questions do not automatically become problems. A teacher may ask, "How do the people of Canada get their drinking water?" only to discover that few children care. Children are more interested in small and immediate problems: "How can fish stay under water?" Teachers should always re-examine the problems they intend to use to be sure that they have problems which challenge the pupils.

### Answering Questions

It is a matter of courtesy to recognize all questions that pupils raise, whether the questions seem relevant or irrelevant, intelligent or silly. Perhaps if we could know all that goes on in a child's mind we would consider all his questions more seriously.

Recognition of a question does not mean that the question must have an immediate answer. Teachers probably answer too many questions for the good of the child. When a teacher answers a question, or selects one of the pupils' guesses as correct, there is nothing more for the pupil to do. It is better to encourage him to speculate, experiment, observe closely, and turn to recognized authorities for information to answer his own questions.

The more a teacher knows of a subject the easier it is to avoid the direct answer in favour of suggestions for finding answers independently. But when a teacher's background in a field is limited, it is still possible to make suggestions that send a pupil to experiments and to books for information—and for the answers.

A teacher must often say, "I don't know, but . . ." and follow up with suggestions for planning an experiment, or with the name of a recognized authority. There are innumerable questions that neither the teacher nor anyone else can answer. Physicists do not know why a magnet picks up iron. Biologists do not know why a bobolink migrates to South America in autumn. No one knows why the earth pulls things toward it or how a green plant produces sugar. The teacher must never be afraid to say, "I don't know." These are the words that challenge mankind. Perhaps that teacher's pupils will be the very ones to solve these age-old questions.

### Experiments

Children love to experiment—to find out by "doing," as compared with learning through reading and being told. This is because children like to manipulate, they like to see things happen, there is an element of suspense involved, and perhaps they subconsciously recognize the validity of information gained this way.

Experiments in the elementary school should be informal. Problems are best stated in the words of the children. There is no place for the formalized pattern of "objective, apparatus, procedure, observations, and conclusions."

The best problems for experiments are the small problems that can be solved with simple equipment and in a short time. "Can a magnet attract a paper clip through cloth?" "Will grass turn yellow when a board is laid on it?" "Will cocoa pass through a filter?"

A number of worth-while problems arise from discussions that pupils hear at home. "Does hot water freeze faster than cold?" "Will aspirin tablets keep cut flowers from wilting?" "Is the coldest place in a room near the floor?"

Certain problems are too broad for children to solve. "Do plants need light in order to live?" "Does a fire need air in order to burn?" It would be improper to let pupils feel that they had answered such questions after two or three experiments. Instead of such problems, pupils should be encouraged to work on more limited problems. "Do bean seeds need light in order to start growing?" "Will a candle burn longer in a quart jar than in a pint jar?"

While pupils are carrying out an experiment, the teacher should refrain from influencing their conclusions. Only after the pupils begin to discuss their results should the teacher begin to raise questions that will encourage them to modify their conclusions. Perhaps the pupils have discovered that a pot of corn seedlings in a dark closet died after six days. Some of the pupils have decided that corn seedlings need light in order to live. The teacher may now suggest that the seedlings might have died anyway, perhaps because the soil was poor. She may then encourage the pupils to set up the experiment with another pot of seedlings in a light place.

Teachers are sometimes upset because an experiment does not "work." Actually, all experiments "work" in that they show that something happens or fails to happen. When an experiment does not turn out as anticipated, it is because some unconsidered factor has entered or because the expected result is wrong. But that is the fun of experimenting, not knowing what the results are going to be and trying to account for what does happen.

### Field Work

The Exploring Science Series encourages field work as one of the most effective methods of learning science. Few are the units that do not suggest directly or indirectly some type of field work.

Possibilities for field work are almost endless. School buildings often have heating systems, gymnasiums, shops, kitchens, medical centres, and fire protection devices. School yards frequently have play equipment, flagpoles, shaded and unshaded areas, and varying kinds of vegetation.

Near schools there are often parks, gardens, vacant lots, and fields where plants can be studied. Where there are plants there are insects and other animals. Near schools there are sometimes automobile service stations, stores, greenhouses, and other business establishments. These present many opportunities for the study of science.

Field work should be planned carefully. Children should know what they are to look for. Do crocus blooms stay closed on cloudy mornings? How is air put in a tire? These are simple, direct problems well fitted for field investigations.

Outdoor experiments make good subjects for field work. The pupils may compare the temperatures of pans of water in sunshine and in shade. They may study the effect of sprinkling water on a pile of soil.

Field work is usually more effective when each pupil has something to do with his hands. The children may collect coloured leaves. They may take the temperatures of the soil in different places. They may write the answers to questions formulated before the trip.

Techniques for handling pupils in the field are somewhat different from handling pupils in the classroom. Each pupil must have something to do and he must know exactly how to do it. One of the important differences between indoor and outdoor situations concerns the amount of talking by the teacher. Lecturing and class discussion usually fail in the field because there are so many distracting elements. These techniques should be reserved for the preparatory and follow-up lessons. Once in the field, the teacher should generally talk only with individual pupils who come up with special questions.

### Science Projects

Science projects exist in such rich variety that it is possible to appeal to the many interests and talents in a class. Children who like to work with tools enjoy making models. Children who like to draw and paint enjoy making posters, charts, and friezes. Children who like to write find opportunities to write stories and plays. Children who like to collect will enjoy preparing exhibits of their science collections.

Science projects such as these encourage pupils to plan, to use ingenuity, to persist at a job until it is done. Group projects give children opportunities to work together, to share, to assume leadership. The final products are tangible evidence of accomplishment and give the children deep satisfaction.

Such projects are important in the learning process. They bring together information and organize it in easily understood patterns. Often the projects give rise to new problems for the pupils to work on.

Completed projects should be put on exhibition whenever possible. Projects may be displayed in the foyer of the school, at Parents' Nights, and at P.T.A. meetings. They may be exhibited in store windows during Education Week. Local newspapers are usually delighted to publish photographs of exhibits and the children who made them; the teacher need only call up the editor and notify him of the displays. Through projects of this kind, parents gain a better understanding of what goes on in the school programme, and children enjoy sharing their science experiences with them.

## CONSERVATION EDUCATION

Elementary science should make significant contributions to conservation education. Science deals with plants and animals, rocks, soil and water, and with the scientific principles that control these natural features. Science helps meet the three general objectives of conservation education—1) to give information about natural resources, 2) to develop desirable attitudes towards the use of natural resources, and 3) to give experiences with conservation practices.

Studies of the life histories of living things give an understanding of their problems. Each book of the Exploring Science Series includes a number of life history studies, and others are suggested in the Teachers' Editions.

Interrelationships among plants, animals, and their natural environments are also important. Better understanding of interrelationships would have prevented the admission of many animal and plant pests into this country, the extinction or near extinction of many species, and the many other mistakes we have made in handling our environment. This Series stresses interrelationships in all units dealing with the natural environment.

In general, when pupils gain sufficient backgrounds of information they develop proper attitudes. Having seen a badly eroded pasture, having learned the value of topsoil and the difficulty of replacing it, they recognize the waste and the need for conservation practice. They need no indoctrination; they draw their own conclusions from the facts.

These books also show children how to practise conservation for themselves. They are encouraged to take care of their clothing and their toys. They learn to conserve heat by closing doors and windows in cold weather. They are instructed in the prevention of grass fires and forest fires. They learn how to co-operate in fire prevention about the home.

Children are also encouraged to help to keep streets, roadsides, parks, and picnic grounds free from litter. Much education is needed in the proper use of one of our great resources, the beauty of the countryside. By taking pupils to places that are beautiful and then for contrast to places that have been abused, the teacher gives them training in an important area of conservation education.

## HEALTH AND SAFETY EDUCATION

All areas of the elementary school curriculum must share in the responsibility for helping children to learn to take care of themselves. Science is especially important since it contributes much of the informational background necessary. By broadening its goals, the teacher may use science as the basis for the health and safety programme when classroom time does not allow for two separate programmes.

These are the areas commonly included in health and safety programmes for the elementary school:

The meaning of health
Body growth and development
Nutrition
Circulation and respiration
Digestion
Elimination
Bones (including teeth) and muscles
Skin, hair, and nails
The senses
Ears, nose, and throat
Rest and relaxation
Mental health
Sanitation
Communicable diseases and their prevention

Tobacco, alcohol, and drugs
Preventing falls
Safety with tools
Preventing fires
Traffic safety
Treatment of small wounds
Prevention of sunburn
Water safety
Safety with animals
Safety with electricity (including lightning)

The Exploring Science Series provides a combined science and health programme when such a combination is desired. Most of the units in each book contain health and safety material. For instance, the fourth-grade unit "Static Electricity" includes a lesson on safety during a thunderstorm. The sixth-grade unit "Water in the Ground" includes several lessons on safe drinking water. In addition, each book contains one or more units dealing primarily with health and safety, which are noted at the end of each book under "The Major Topics Presented in Each Unit." Thus a complete integration of the two programmes can be carried out in a completely natural way.

The flexible organization of the books permits the emphasis to vary according to need. If the school provides a separate health and safety programme, only a minimum amount of time need be spent on repetitious material in this Series. But if the combined programme is in operation, the health and safety material may be expanded as desired. The special helps in the Teachers' Editions show how to make the most of situations that arise from working with the Exploring Science Series.

It should be remembered that the science programme cannot assume the complete responsibility for health and safety education. Health and safety instruction must go on at all times. Children need orientation in the use of drinking fountains, public toilets, and school washrooms. They must be reminded constantly about washing after playing with things that dirty their hands, after going to the toilet, and before eating. They must be encouraged to play actively and then rest quietly. Safety in the classroom and on the playground must be stressed constantly. And the whole problem of mental health—good social adjustment, self-confidence, self-reliance—should be an every-minute-of-the-day concern of the teacher.

# Detailed Teaching Suggestions for Book Six

As a group of pupils advances from grade to grade, the spread of their individual differences continues to widen at an ever-increasing rate. In part, this is due to the increasing diversity of experiences that pupils have outside of school. In part, it is due to the discovery and development of special talents. And it may be due in part to actual regressions as pupils become discouraged and antagonistic towards certain aspects of school work.

By the time pupils have reached the sixth grade, the wide range of their interests and abilities should have a profound effect on the science programme. Certain pupils have become deeply interested in such topics as birds and wild flowers; others seem to care little for any subjects except astronomy, or airplanes, or chemistry. Some of the children read avidly and turn to books for information with pleasure; others refuse to interest themselves in any type of reading material. Some children have a love for painting, some for model-making, some for collecting. On the negative side—all too many are beginning to avoid the use of hammers, saws, and similar tools, and some are developing strong aversions for snakes, fishworms, and insects.

The sixth-grade teacher must be concerned with individual differences in the science programme. She must make the best use of all these diversified interests and abilities, helping each child to grow to the utmost along his specialized line. She must also broaden the interests and abilities of each pupil using the work of one child to interest another so that she can encourage reluctant readers to read, mechanically inept children to use tools, and prejudiced little girls to look at snakes with less horror.

The common denominator of interest in the sixth grade is the direct learning experience—the experiment, the demonstration, and the field trip. A topic introduced through such first-hand experience has general interest. From the common core of learnings so established the pupils can diverge in the ways that benefit each the most.

The separate units of *Exploring Science Six* are based upon direct-learning experiences. Discussion, reading, and telling are to be used to supplement information gained at first hand. The specific directions that follow show how to begin with the common core of experiences and develop the topics in various ways.

Sixth-grade pupils benefit most from simple, direct types of activities. Many children are confused by activities that involve abstract ideas and several steps in reasoning. On the other hand, it is a mistake to insist upon work that is too elementary. If the pupils know the outcome of an activity beforehand, there is little challenge to them; there should be something new to look for in each activity.

It is not unusual to find a sixth-grade boy or girl who has developed interests and abilities far beyond those of the remainder of the class, and who may know more about certain topics than the teacher herself. These pupils need special treatment because it is on such individuals that future scientific progress depends. To force them to participate on the same basis as the others is to stifle them. They need all the encouragement that can be given. Such pupils can help to teach the subjects they know about, they can prepare special projects, they can take extra responsibilities. The teacher may not be able to help them very much in their special fields, but she can give them opportunities to work and recognition for their achievements.

No outcome of a science programme can be more important than the development of critical thinking. Never underestimate the ability of sixth-grade pupils to think clearly. Children are naturally cautious about making statements unless they are encouraged into fuzzy thinking by adults.

Pupils should not be hurried into making unjustified statements and unwarranted generalizations. They should be encouraged to test and retest their conclusions, never feeling satisfied with statements that are too broad for the data collected. The teacher can and should set the example herself by being sceptical and demanding proof, and by being less interested in broad principles that cannot be substantiated in the classroom than in limited principles that the pupils can prove.

Verbalization in the science programme is always of secondary importance. It is much more important for pupils to have had an experience than to be able to talk about it. None the less, sixth-grade boys and girls should be developing a certain amount of verbal ability. Teachers can take advantage of the strong interests developed in science to help children to learn to express themselves.

Fortunately, the common phenomena of science can be described and explained in simple language. No highly specialized vocabulary is demanded. Pupils can talk about non-green plants and seeing with two eyes without using such words as "chlorophyll" and "binocular vision." There will be pupils who are ready to add such words to their vocabularies, but others in the class should not be pressured into using them.

The general reading level of Book Six is kept well below that of readers designed for Grade Six in order that no pupils be handicapped by the mechanics of reading. For the more advanced readers, a list of suitable books is included at the end of each unit in this Manual.

Teachers who are required to give instruction in the effects of alcohol will find suggestions for incorporating such study into the science programme on pages 25 and 31 of this Manual.

## SCIENCE DEFINITIONS

To facilitate the introduction of certain scientific terms—and for emphasis—they have been set in bold-face type the first time they occur in the text. These 18 terms comprise the special science vocabulary introduced and developed in *Exploring Science Six.* Their definitions are starred in the list below, and the page on which each first occurs is included after the definition. Other scientific terms which appear in the text are also included in the list below; the teacher may wish to give added emphasis to these as well. The language in which all these terms are defined is language which the children will readily understand.

* **acid**—A chemical that unites with baking soda and gives off carbon dioxide gas. Acids are sour to the taste. Vinegar is sour because of the acid in it. (Page 162)

**bacteria**—Tiny living plants found almost everywhere. Some bacteria are useful as are the bacteria that make vinegar. Some are harmful as are those that cause typhoid fever. Most bacteria are harmless.

* **bearing**—The part of a wheel that rubs against its axle as it turns. Sometimes small steel balls or rollers are used in the bearing of a wheel so the wheel turns easily. (Page 129)

**bladder**—A soft, thin bag that holds liquids or gases in the bodies of animals. The air bladder of certain fish makes them float when they do not use their fins to stay down.

**bog**—A piece of wet, soft, spongy ground. The soil in bogs is usually acid.

* **carbon dioxide**—A common gas given off by the action of acids on baking soda, by animals when they breathe, and by the burning of coal or wood. (Page 22)

**concrete**—A mixture of sand, gravel, cement, and water that hardens as it dries. Sidewalks, foundations of buildings, and many roads are made of concrete.

**condense**—To change from a gas to a liquid, as when water vapour changes to liquid water.

**conservation**—The wise use of things so that there is no waste. Forests, coal, oil, soil, and minerals should be conserved.

**contour**—A line round a hill that is always on the same level, that does not go up the hill or down the hill.

* **contour ploughing**—Ploughing along a slope so the furrows follow a level line round the hill. Contour ploughing helps to save the soil. (Page 45)

**crane**—A machine with a long swinging arm for lifting and moving heavy objects.

**curdle**—To make milk separate into curds and whey. The curds are the thick part of the milk; the whey is the thin, watery part.

**digest**—To change certain kinds of food into forms that can be used in the body. In our bodies most food is digested in the stomach and the intestines.

**dissolve**—To become part of a liquid, as when sugar is dissolved in water.

**electromagnet**—A magnet formed when electricity flows through a coil of wire. The coil stops being a magnet when the electricity stops flowing.

**energy**—The ability to do work. Gasoline has energy that makes an automobile move.

**erosion**—The wearing away of rocks and soil by wind and water.

**evaporate**—To change from a liquid to a gas, as when water changes from the liquid state to water vapour.

* **friction**—The rubbing together of two objects, as when a box is dragged over the floor. Friction makes it more difficult to move things. (Page 126)

**geyser**—A hot spring that sends up a fountain of hot water and steam at intervals. (See picture on page 298.)

**gill**—A part of the body which takes oxygen from water. The gills of fish can be seen when the fish opens the gill covers on the sides of its head. (See picture on page 309.)

**gland**—A part of the body that makes and gives off a liquid. In our mouths saliva glands give off saliva that moistens the food we eat.

**grain**—The lines in wood. (See pictures on pages 340–341.)

**hail**—Small balls of ice that fall from the clouds, usually during thunderstorms.

**hard water**—Water that contains dissolved minerals, usually those from limestone. More soap is needed to make suds in hard water than in soft water.

* **humus**—The part of soil that is formed by the decay of leaves and other plant material. Humus gives soil a dark colour. (Page 30)

**insulation**—A substance that does not allow electricity to flow through it. Wires are covered with rubber, cotton, or other insulators to keep electricity in the wires.

* **iris**—The coloured part of the eye round the pupil. (Page 83)

**knot**—The hard mass formed in a tree where a branch grows out and which shows in a board as a round, hard piece.

**lever**—A bar that turns about a point, used to move objects.

**lightning**—A flash caused when a huge electric spark jumps across the sky.

**limestone**—A kind of rock that is made of the same chemicals that make up clam and snail shells. Limestone is often made up of such shells crushed and cemented together.

**magnetic pole**—The parts of a magnet where the magnetic forces seem to be centred. Magnets always have at least two poles, occasionally more. There are only two kinds of poles: south-pointing and north-pointing.

**microscope**—A device used to make tiny things appear large enough to be studied.

**migrate**—To go from one place to another with the change of seasons. Many birds migrate to more southern regions in the autumn and return in the spring.

**mould**—A plant that is often seen growing on food as a woolly or furry growth. It cannot make its own food as do the green plants, but must take its food from other things.

**oxygen**—A colourless gas in the air. Plants and animals must have oxygen in order to live. Oxygen is needed when wood and coal burn. About one-fifth of the air is oxygen.

* **parasite**—A plant or animal that lives on another living thing, taking its food from the thing it lives on. Fleas are parasites on dogs. (Page 334)

**pasteurize**—To heat a liquid hot enough to kill the bacteria living in it. Most milk is pasteurized before being sold.

* **pitch**—The highness or lowness of a sound. A violin makes sounds of high pitch; a bass viol makes sounds of low pitch. (Page 135)

* **pupil**—The black spot in the centre of the eye, in reality an opening in the iris. (Page 83)

**ramp**—A sloping way connecting two different levels of a building or a road.

* **reeds**—Strips of metal that vibrate when air blows past them. Mouth organs and accordions have reeds. (Page 146)

**rotation**—Changing regularly, as when the crops in a field are rotated yearly so that the same crop is not used two years in a row in the same field.

* **screw-jack**—A type of jack used for raising very heavy loads such

as buildings. The force needed to raise the load is made smaller by a screw in the jack. Also called a jack-screw. (Page 114)

* **sheet erosion**—Caused by rain falling on a bare field and washing away the soil. (Page 36)

**sperm**—Tiny particles in the fluid given off by male animals during mating. Sperms must enter eggs before the eggs can develop into young animals.

* **spores**—Tiny particles given off by some plants such as moulds and toadstools. Each spore can develop into a plant. (Page 6)

**spring**—A small stream of water coming from an opening in the earth.

**steel**—Iron mixed with other things, usually carbon, that make it very hard, strong, and tough. Most things that we say are made of iron are really made of steel.

**storage battery**—A device in an automobile that stores the energy of electricity so that the lights, the horn, the radio, and the starter can be used when the engine is not running.

* **strip cropping**—Planting different crops next to each other in strips along a hillside. Strip cropping helps to prevent erosion. (Page 46)

* **subsoil**—The layer of soil that lies beneath the topsoil. Subsoil is usually lighter coloured than the topsoil because it contains less humus. (Page 28)

**switch**—A device used to make an electric current stop and start. The electric lamp in your classroom is turned on and off with a switch.

**telegraph**—A device for sending messages over a wire by electricity, the electricity causing clicking sounds that can be read according to a code.

**teletype**—A device that sends messages by electricity, the messages being written out as though by a typewriter.

* **topsoil**—The top layer of soil. Topsoil usually contains humus and many living things. (Page 28)

**tornado**—A violent whirlwind.

* **vibrate**—To move back and forth rapidly, as a violin string vibrates while it is being played. (Page 132)

**well**—A hole dug or bored in the ground to get water, oil, or natural gas.

**yeast**—A tiny plant that produces carbon dioxide and alcohol when it uses sugar for food. Yeast is put in bread dough so that the bubbles of carbon dioxide given off will make the dough rise.

# Plants That Are Not Green

## PURPOSE OF THE UNIT

Non-green plants play a much more important role in the world than most people realize. They exist in countless numbers almost everywhere. Many of them such as yeasts and bacteria are microscopic, but because of their numbers they have a marked effect on other living things. Most of the non-green plants obtain their nourishment from dead plants and animals, causing decay and releasing minerals needed by new generations of green plants. Some non-green plants are parasitic on other plants, and a few are parasitic on animals.

Non-green plants are of great economic importance. Some make the minerals in organic fertilizers available to crops. Some help to preserve foods—cheeses for man and ensilage for cattle. Yeasts are well known for their part in bread making, and they are essential in the manufacture of alcohol, so vital in industry today. Certain of the non-green plants are harmful as well. Some kinds damage and kill valuable plants. Some kinds cause diseases in domestic animals and in man himself.

This is the first time that this important group of organisms has been considered in detail in the Exploring Science Series. Non-green plants were mentioned briefly in the fourth-grade unit "Soil" and in the fifth-grade unit "Plants and Light." Pupils should be ready now to appreciate the way these plants fit into the general pattern of living things.

This study should give pupils a broader concept of the environment and a heightened appreciation for the way the various factors affect each other. It is to be hoped too that pupils will develop an increased interest in the things around them as they become conscious of the reasons for the "shelves" that grow on trees and the holes in a slice of bread. The section on yeast can be used as part of a sequence on alcohol and drug education. The section on bacteria can be expanded in the study of the relation of bacteria and health.

## PREPARING FOR THE UNIT

It is recommended that this unit be introduced during a period when mushrooms are most easily found. It is easier to begin the study of non-green plants with forms large enough to see without a microscope. In many sections, the fall season is best for finding mushrooms.

One should try to find localities where mushrooms may be found. Dense, dark woodlands give the largest variety and the greatest numbers of mushrooms, but there are usually mushrooms in all localities. Wherever wood is decaying, one usually finds mushrooms of the shelf type. Look on decaying logs, untreated fence posts and pilings, piles of leaves, and pieces of wood in moist places. Lawns rich in organic matter often show mushrooms, too. In cities mushrooms can be found in parks, on the wood of decaying fences, and on buildings and wharves. Mushrooms can also be purchased in food stores.

Most of the equipment needed for the experiments consists of simple things like bottles and drinking glasses. Hand lenses are desirable and a compound microscope is useful for examining some of the smaller forms such as yeast and mould. In the experiment with yeast, a cake of fresh yeast, which may be purchased at a grocery store, is needed. The bread should be of the type that is not treated to prevent mould. Small "home" bakeries provide this type of bread.

**List of Materials**

Drinking glasses
Plates and bottle
Bowl
Soda straws
Modelling clay
Hand lenses
Needles
Candle
Yeast cake
Bread (untreated for mould)
Oranges or apples
Ingredients for bread dough

## TEACHING THE UNIT

It is not necessary that this material be taught in one consecutive block of time. A trip to see mushrooms might be taken in early fall, and a trip to a bakery might be taken in late winter. The experiment with the mouldy oranges might be deferred until an orange with mould on it has been located. This is a flexible unit, its separate topics being most effective when conditions best warrant their study.

Many experiments with moulds and yeasts should suggest themselves to the pupils. It is in the spirit of good science teaching to let them improvise and try out these experiments.

Technical language has been avoided in this unit but pupils who read further will encounter such words as "fungus," "mycelium," and "chlorophyll." Help them to find the meanings of these words in the dictionary and encourage them to use the words, but do not force them upon all members of the class. Many pupils are not ready to add such words to either their reading or their speaking vocabularies.

The special science words in bold face in this unit are "spores" and "carbon dioxide."

**Pages 4–5**

A field trip to find mushrooms is suggested here. A class trip would be the most satisfactory procedure, but when conditions make this impossible, trips with interested children can be taken after school and on weekends. Pupils can also be encouraged to take trips on their own.

The most important outcome of such field study is an understanding of where mushrooms grow. Pupils may like to collect a few of the mushrooms for display, but only the woody forms of the shelf type can be kept for any length of time. Some pupils may like to make paintings of some of the more striking mushrooms.

**Pages 6–7**

Puffballs show more effectively than any other common mushrooms the spores by which mushrooms and other fungi reproduce. Puffballs may be collected in advance and stored for use in this unit in case they cannot be found when needed. Some of the spores may be put under a microscope for study if a microscope is available.

Spore prints of the meadow mushroom shown on page 7 are interesting to make. To preserve the prints, spray them with shellac or an artist's plastic fixative. The colour of the paper used may be varied to provide the best contrast for the spores.

**Pages 8–9**

These pages describe the development of the fruiting bodies of the common meadow mushroom. This mushroom is the one raised and sold commercially. Several stages of the development can be seen in one basket of mushrooms. These mushrooms are common in pastures and lawns that contain much organic matter.

Some seedsmen and nurseries sell at low cost trays of organic soil with mushroom "spawn." It is only necessary to moisten the soil and keep it in a dark, warm place before the mushrooms begin to form.

If there is a commercial mushroom-raising plant in the community, one can usually get a small amount of soil, some "spawn," and directions for raising some mushrooms in the classroom. Sometimes it is also possible to arrange for a trip to the plant.

**Pages 10–11**

The concepts developed on these pages are made more meaningful if they are illustrated by first-hand experiences. Trips to see decaying wood, particularly if mushrooms are showing on the wood, are especially helpful. A rotten log can be torn apart to show the threads (mycelia) that make up the plants. Rotted limbs can be broken to show how the wood has been weakened. Fence posts, boards left on damp soil, poles driven in wet soil, and floor beams of small buildings that rest on the ground show the rapid decay of wood when various non-green plants begin to grow in them.

Telephone poles and railroad ties provide the most common illustrations of the methods used to preserve wood from the attacks of non-green plants. Pupils can carry out an experiment with both of these methods. They will need soil in a large container such as a gallon mayonnaise jar or paste jar. They will also need some preservatives such as paint or the chemical solutions (creosote, cuprinol) used for fence posts. The latter can be purchased in building supply stores, or the small amount needed can be requested of a farmer who dips his own posts. There are also other solutions used by contractors who erect wooden buildings. A few pieces of wood should be treated according to the directions given on the containers; other pieces should be left untreated. All these pieces of wood are then buried in the damp soil, a cover is put on the container, and the wood is left for two or three months in a warm place. The progress of decay can be checked occasionally.

**Page 12**

Many people collect and eat wild mushrooms, some of which are delicious. However, it is not wise for children to eat wild mushrooms. Even adults should collect only those they know to be safe. There are many so-called "rules" that are supposed to distinguish between safe and poisonous forms, but some of the rules are without any foundation of fact and others are not positive. Pupils should understand these limitations thoroughly because some forms are deadly and many make the eater very sick.

### Page 13

Fairy rings are frequently seen in pastures and lawns rich in organic matter. If a fairy ring is found near school, try to take the pupils to see it or tell them where to see it. An understanding of its growth is very helpful in developing an appreciation of the underground nature of the plant.

### Pages 14–15

If possible, take the children to see bracket fungi or "shelf mushrooms," as they are sometimes called. Bring in specimens for display. Let the pupils break one of them open to find the tubes where the spores are formed. In the case of the woody forms ask them to determine the age of the shelves. Sometimes when the wood where the shelf is growing is well decayed, it is possible to tear it apart and find the plant within.

If pupils understand how non-green plants gain entrance to the wood of a tree, and if they understand how the wood and the tree are affected, they will know why they should not carve initials in the bark of trees, or chop away part of the bark, or do other things that expose the wood of a tree. They will also understand why people paint wood which has been exposed after limbs are cut and bark is knocked off.

It may be possible to arrange for a talk and a demonstration by someone from a tree repair service.

### Pages 16–17–18–19

Mould on bread is not so common as it once was because commercial bakeries add mould-inhibiting chemicals such as sodium propionate to the dough. Bread still makes a good medium for mould experiments, and one can get suitable untreated bread from small "home" bakeries. Slices of boiled potato are also satisfactory.

Although some moulds have a greenish tinge, this colour is not due to chlorophyll; moulds cannot manufacture their own food. Explain to the pupils that green moulds are not considered to be "green" plants.

Pupils will usually bring in samples of food on which mould is growing, such as jam, cheese, and pickles. If these samples are put in closed glass jars and kept in shaded or dark, warm place, the mould will grow luxuriantly. Other foods can be inoculated with bits of mould from the original samples.

Encourage the pupils to experiment with different factors that might affect the growth of mould. The effect of moisture, light, and low temperature are suggested in the text. They can also experiment with the effect of high temperature, the effect of sunlight, the effect of antiseptics, and other factors they might think of.

**Pages 20–21**

An orange with mould on it can usually be found in a fruit store. Instead of using oranges, apples that are beginning to rot can be used.

After carrying out the experiment as described, the pupils may vary the experiment by dipping the needle in some strong antiseptic such as iodine, instead of heating it. They may also wash the needle with soap and water instead of heating it.

Discuss at this time ways in which harmful bacteria enter cuts in the body, and refer the pupils to first-aid books for information on treating cuts. Arrange for a demonstration of the methods used in opening and applying packaged bandages to wounds so that contamination is prevented. The school nurse or a first-aid specialist can give excellent help with this topic.

**Pages 22–23–24–25**

Instead of using a soda straw and modelling clay to show that a gas is given off by yeast in a sugar solution, one may use a bent glass tube and a rubber stopper. These last may be borrowed from the science department of a high school. The glass tube and rubber stopper are more satisfactory.

Either dry yeast or fresh yeast can be used in these experiments, but the latter is quicker-acting and is recommended. If a microscope is not part of the school equipment, one may often be borrowed from the high school science department. Many children have toy microscopes that will serve to show the nature of the yeast plants and their method of reproduction. A water-drop microscope is easy to make and gives enough magnification to show the yeast plants. Punch a small hole in a strip of metal with the point of a small nail. File off the projections on the under side, then bend the metal as shown in the picture. Lower a drop of water into the hole with the point of a pencil. A bit of yeast and water mixture may be put on a piece of glass and held under the water drop for examination.

To show the pupils that yeast is alive, repeat some of the experiment using yeast that has been heated to boiling, and yeast that has been killed with antiseptics.

Many local bakeries are pleased to arrange for a visit by the children. It is advisable for the teacher to go through the plant once beforehand if this is possible.

If in the combined health-science programme the study of alcohol is included as an essential topic, use this opportunity to expand the pages on the growth of yeast. Encyclopedias give information on the commercial production of alcohol for industrial purposes and they show how alcohol is extremely important in industry today. The encyclopedias will also give information on the production of beer, wine, and other alcoholic beverages. Pupils may make reports on these industries.

The effects of alcohol on the human body should be considered at this time, stressing the impaired sense of balance and co-ordination, the dulling of judgment, and the tendency towards drowsiness that attend the use of alcohol. The pupils should discuss the importance of these qualities in our mechanized society and why there are rules prohibiting the use of alcohol by bus drivers, truck drivers, and pilots while at work. Local laws and penalties for driving while intoxicated should certainly be investigated. Statistics on automobile accidents caused by drunken driving, and on fires caused by drunken people, can be collected from insurance companies, the police, and such organizations as the Canadian Automobile Association.

The problem of alcoholism may be touched upon, but it is too complex a subject for sixth-grade children to deal with adequately. They certainly cannot appreciate the psychological causes of alcoholism and we do not want the science programme to deal with the morbid and the sensational.

The effect of alcoholic beverages on our economy is also complex and difficult to study. Some statistics may be helpful. Such organizations as the Woman's Christian Temperance Union will give data on expenditures for alcohol compared with expenditures for schools, libraries, and hospitals. The cost of alcoholic beverages can also be compared with things the pupils are acquainted with such as sporting goods, bicycles, and musical instruments. Such information helps the pupils to understand that drinking at best is an expensive luxury, and that it is easy for financial hardship to result from excessive use.

**Page 26**

Depending upon the interests and abilities of the children, this section on bacteria may be expanded a good deal. The useful aspects of bacteria should be stressed as much as the harmful aspects. More important from a practical standpoint is a consideration of some of the aspects of sanitation. If the pupils understand that bacteria are plants, they will understand many health practices such as chlorinating public water supplies and boiling doubtful water supplies in the home. They will understand why disinfectants are used and why milk is pasteurized.

### Summary Questions

1. Green plants can make their own food, but other living things must get their food from green plants, either directly or by feeding on forms that eat the green plants.
2. Most kinds of mushroom plants get their food from dead organisms, usually dead plants. A few kinds get their food from living plants such as trees.
3. Spores are tiny particles given off by some kinds of plants. The spores are capable of producing a new generation of plants.
4. Yeast is put in bread to make it rise. The bubbles of carbon dioxide given off by the yeast cause the expansion of the dough.
5. Yeast plants multiply by buds that break off and become new yeast plants.
6. Bread, fruit, and pickles are made less desirable by mould growing on them. Certain cheeses are given their special flavours by particular moulds.
7. Wood in damp places decays because plants that are not green use the wood for food.

### Follow-up

Pupils should be on the alert for mushrooms, and they may tell others in the class about them, bring in samples, or arrange for class visits. The same is true of evidences of decay in wood.

Pupils will often find mould at home and they may bring it to school for display. Sometimes these contributions will suggest a new set of experiments.

## POSSIBLE LEARNINGS

Green plants can make their own food.
Plants that are not green must get their food from other sources.
Decay of dead things is brought about chiefly by plants that are not green.
Soil is enriched by the products of decay.
Decay is harmful to man when it affects objects made of wood.
Moisture is essential for decay.
Mushrooms are the fruiting bodies of certain non-green plants.
Trees are infected by non-green plants through wounds in the bark of the trees.

Many non-green plants reproduce by means of spores.
Yeasts give off carbon dioxide and alcohol.
Yeasts are used to make bread rise.
Bacteria are tiny non-green plants.
There are harmful and useful non-green plants.

## BIBLIOGRAPHY

### Books

*Audubon Nature Bulletins.* Prepared and published by National Audubon Society, New York. 4 pages each.
Several of the bulletins contain background information to supplement this unit. List sent by the Society on request.

*Dependent Plants.* Bertha Parker. Copp Clark: Toronto, 1944. 35 pages.
A brief description of some parasitic plants including mushrooms, moulds and bacteria.

*Handbook of Nature Study.* Anna Botsford Comstock. Thomas Allen: Toronto, 1947 ed.
Valuable for general reference and as a teaching guide. An up-to-date natural history library in one volume.

### Films

*Alcohol and Tobacco: What They Do to Our Bodies.* Coronet.
The dangers of the use of alcohol and tobacco; a film that can be used with this unit in a programme of alcohol and tobacco education.

*Fungus plants.* Encyclopaedia Britannica Films.
Growth of mushrooms, moulds, and other fungi shown by time-lapse photography.

*Mould and Yeast.* Encyclopaedia Britannica Films.
Development of yeasts and moulds; photomicrographs of yeasts showing budding.

# Saving the Soil

## PURPOSE OF THE UNIT

Our soil is one of our most important natural resources, but because it is so common and because it is so little understood, people are generally unaware of its significance. There is also a tendency to assume that soil is important only to the farmer rather than recognizing it as a national asset on which the well-being of everyone depends.

Sixth-grade pupils cannot apply immediately the principles of soil conservation, but in about ten years they will be voting citizens and some of them will be practising farmers. Schools must give them the information needed for intelligent decisions and help them to develop desirable attitudes toward the problems of soil conservation. Ten years is none too long a time to do this effectively.

Previous units have been designed to develop understandings that will be useful in teaching this unit. The third-grade unit "Muddy Water," the fourth-grade unit "Soil," and the fifth-grade unit "Streams at Work" form a sequence leading to this unit. The importance of soil is also stressed in other units such as the third-grade unit "Grass."

The experimental method is used extensively in developing this work on soil conservation. Pupils can be given practice in considering factors that affect experiments, and they can be given practice in setting up controls to make conclusions more valid. The pupils will also have numerous opportunities to apply the results of their experiments to everyday situations.

The experiences suggested here should help greatly in developing the interest of pupils in their surroundings. Evidences of soil erosion are plentiful everywhere. Because the pupils will understand some of the causes and the mechanics of erosion, and because they will recognize some of the practices used to check erosion, they will be more alert to the numerous examples which they will encounter.

## PREPARING FOR THE UNIT

This unit is best taught during a season when other outdoor work is possible. Many field trips will suggest themselves, and many experiments are better carried on out-of-doors where water and soil can be spilled without regret. It is recommended that the unit be taught in the fall, so that there can be a long period of follow-up.

It is well to begin planning possible field trips when school opens in the fall. Examples of miniature gullying are commonplace wherever there are slopes of bare soil, such as the slopes of newly-constructed terraces, embankments, and piles of soil. Large-scale gullying may be seen within quick walking distance of many schools. Contour ploughing, strip cropping, check dams, and similar practices are becoming increasingly common.

The federal government subsidizes in each region of the country a number of demonstration farms where soil-conservation techniques are practised. A trip to one of these farms is especially valuable. The local agricultural agent will help to make arrangements for such trips. If the school does not have buses for transportation, parents may be willing to drive their cars.

Some of the suggested experiments call for two trays that are closed at one end and covered with screen at the other. They are simple in design and pupils can make them if the materials are supplied. Rough lumber is satisfactory, especially if the trays are to be used outdoors. Trays three feet long, one foot wide, and three inches deep have been found satisfactory, but smaller sizes may be used.

When the experiments are carried on outdoors as recommended, it is helpful to have a hose and fine spray nozzle to simulate rain. However, cans with nail holes punched in the bottom can produce a good "rainfall."

**List of Materials**

Lumber for erosion trays
Screening
Nails
Tacks
Hammer
Saw
Shovel
Hand lenses
Plant pots
Tin cans
Glass jars
Topsoil
Subsoil

## TEACHING THE UNIT

Numerous first-hand experiences will add to the success of the unit. Field observations and experiments give the necessary background, and pictures, films, and pamphlets serve to broaden the understandings.

If possible, introduce the unit with a trip to see a field that illustrates the damage done by gullying or sheet erosion. Otherwise, use pictures that develop the same understandings.

It is sometimes possible to use outside experts in treating this subject. A local agricultural agent or an agriculture teacher may be willing to talk with the pupils or show them films or slides of conservation practices.

The technical language used in the reading matter of this unit is held to a minimum—only a few scientific words are introduced: "sheet erosion," "contour ploughing," "strip cropping," "topsoil," "subsoil," and "humus." Other words will be encountered in reference books, and these words may be used during discussions by those pupils who are ready to add them to their general vocabularies.

**Page 27**

The picture on this title page may be used to initiate a discussion of the damage that gully erosion can do to fields. Talk about the causes of the gullies first, then the steepness of slope, and the obviously recent hard rain. Comparison of grassy areas and ploughed areas should follow, noting that there is no gullying of grassy areas. The pupils will notice that gullies did not form in the ploughed field at the right and they should speculate on the reasons. Probably the most important reason is the short distance in which streams can flow before being checked by grass. The last assumption is borne out by noting the large gully that formed in the wagon track that goes up the centre of the picture, a track that permitted a stream to grow in size and erosive power as it descended the hill.

Discussion should then centre on the damage done by the erosion. Any crops already planted have been washed out of some places. Ploughing and cultivating will be very difficult where the deepest gully was formed. If the soil is not very deep, rocks are exposed and there is less soil for plants to grow in. And the fields at the bottom are covered with mud and gravel.

**Pages 28–29**

It is usually easy to distinguish topsoil from the underlying subsoil by colour. Topsoil is darker because of the presence of decaying plant material. In most sections of the country one need dig down only a few inches or a foot to turn up the lighter-coloured subsoil. In gardens or ploughed fields it usually lies at the bottom of the cultivated layer. In a few regions it may be too deep to dig up by hand.

The line between topsoil and subsoil may be seen in fresh excavations such as those made for cellars and roads. If an excavation has been made near the school, take the class to see it. The children may collect samples of the topsoil and subsoil. They should notice the depth to which plant roots go, and if some roots penetrate the subsoil, they should notice whether there is a change in their colour.

In many regions hillside erosion has removed so much topsoil that colour differences can be observed in a cultivated field, the upper portions of the field being lighter that the lower, and shallow gullies between the rows showing the light subsoil.

Children who live in newly developed residential areas may have had experiences with topsoil. Many contractors spread the subsoil that is taken from cellars or foundation excavations without regard for the topsoil already on the property. The owners must then buy at high cost more topsoil to cover the subsoil in order to have lawns and gardens.

### Pages 30–31

Topsoil differs from subsoil in many ways, most of which result from the presence of living things in the upper levels of the soil. The presence of decaying organic material gives the topsoil a darker colour. It also changes its texture, making it crumble more easily. It makes clay soils less heavy and gives them better drainage. It helps sandy soils to hold moisture better.

Living things add to this decaying material in the soil when they die, and they distribute other decaying material through the soil while they are alive. In a bushel of rich topsoil the pupils will find many organisms. There will be countless others too small for them to see. See under pages 32–33 for discussion of humus.

If the subsoil in the region is a clay type subsoil, as it usually is, the pupils will find that chunks of it break apart with difficulty, that it becomes sticky and gummy when wet, that balls of it are very hard when dry, and that it tends to cake and crack when it dries after being saturated. The topsoil may possess these same properties but to a much lesser degree, depending upon the amount of decaying organic matter in it. Woodland soil and greenhouse soil may be studied as examples of loose, easily-worked soils.

The experiment with the growth of plants in subsoil and topsoil should be continued long enough for positive results. If the weather is not too cold, the pots should be kept outdoors in full sunlight so that the light factor does not affect the growth.

### Pages 32–33

Plants and topsoil are interdependent. Plant growth is affected by the condition of the topsoil. The topsoil is affected by the amount of plant growth. A topsoil that is rich in decaying organic material is porous, holds moisture without being saturated, is easily penetrated by roots, and contains many minerals that plants need for growth.

Plant roots in turn penetrate clumps of topsoil and the upper part of the subsoil, thus loosening the soil. When the roots die, they change to humus, and the openings left allow rain water to trickle in. Thus, the topsoil is continually improved by undisturbed plant growth, and the plant growth in turn is favourably affected.

It is difficult to define humus exactly. It is a stage in the decay of organic matter, a stage that is near the end of the process. The organic matter is in fine particles and the original source would be difficult to determine. With continued decay the humus changes to gases and water and disappears from the soil.

One can find soil that is largely humus under decaying leaves in a woodland or in compost heaps made by gardeners. Humus for houseplants is also sold in garden stores and florist shops. Very fine peat moss will give soil many of the characteristics that humus gives, and the peat moss quickly changes to humus. Encourage the pupils to add varying quantities of humus to a clay subsoil and note the changed qualities: the lighter texture, the looseness, the lessened tendency to clump in hard masses, the absorption of rainfall, and the changed drainage.

**Pages 34–35**

Gully erosion can be observed in miniature in almost any fresh excavation after a heavy rain. It is also possible to make a pile of sand and sprinkle it with water from a hose or a sprinkling can to produce gullies. In the classroom, a small pile of sand in a large pan will show gullies after being sprinkled with water.

One important concept to be developed at this time is that a gully continues to grow with each rain. When possible, mark with stakes some gullies in a nearby excavation, and notice their growth with each new rainfall.

**Pages 36–37**

Sheet erosion is much less spectacular than gully erosion, but it is responsible for untold losses of topsoil. The simple experiment with a pan of soil demonstrates how soil may be lost through spattering. Visits to patches of bare soil after a heavy rain will show similar effects. The foundations of a house, posts, trees, and sidewalks often show spattering effects, sometimes to heights of two and three feet. It is easy to see how, on a slope, the spattering would tend to move soil down the slope even when there is no running water. (In the picture at the bottom of page 36, the stone has been removed from its "pedestal" of soil to show the action of the rain.)

In hilly regions where the soil is thin, one will often find slopes that are almost denuded of soil. Perhaps a trip to see one of these slopes will be possible.

**Pages 38–39–40–41**

Pupils should realize by now that loss of vegetation increases the loss of topsoil. These pages illustrate two ways that vegetation may be killed and the soil damaged. Over-grazing has long been a plague in many regions. Its effects increase rapidly as soon as vegetation begins to disappear. With the loss of some of the plants, the animals graze more heavily on the remainder, killing them at an increasing rate. At the same time the topsoil begins to erode, and it becomes increasingly difficult for vegetation to re-establish itself. Grazing areas are damaged for many years and may never be restored to their original productivity.

Grass fires started accidentally and deliberately have the same effect; vegetation is killed, and humus is destroyed. Sometimes burning is justified when the expense of clearing a field of dead weed tops and tall grass prohibits cutting and raking, but repeated burnings are a mistake as has been demonstrated again and again.

If there is a burned field near the school, visit it and note the effects. Note the absence of dead vegetation that would eventually become humus. Compare the area with an adjacent unburned area, noticing dead plants and the condition of the soil.

The effects of forest fires are the same as those of grass fires with the additional loss of trees. Very hot fires may burn out the humus to a depth of several inches. With the loss of cover, topsoil erodes rapidly.

**Pages 42–43**

The experiment described here can be very convincing. With even a slight slope, the loss of soil from the one tray is severe, and the loss from the other tray is almost impossible to detect. Water loss will differ also.

Use any type of soil that is common to the region. Large stones and pieces of vegetation should be taken out, but it is not necessary to remove all pebbles. Pack the soil lightly into place in each tray. The sod may be taken from the edge of a flower bed or garden where the lawn has encroached. It is also possible to plant grass in one tray and repeat the experiment after the grass has grown to the height of an inch or so. An extra tray will then be needed for experiments suggested on the following pages.

Encourage the pupils to vary some of the factors in this experiment. They may change the slope by using blocks of different sizes. They may vary the intensity and duration of the "rainfall." The water losses may be bottled and put on exhibit, with labels describing the conditions imposed in each case.

It is not necessary to be in the country to see the effects of poor soil on plant growth. Most school lawns are deficient in essential minerals, and a sparse growth of weeds is the result. There may be lawns near the school that afford comparison between a dense growth of grass and a sparse growth of weeds.

### Pages 44–49

The experiment suggested here to show the effect of cultivating across the slope and down the slope demonstrates effectively how a little care can save untold quantities of topsoil. It also shows that with a steep slope and a heavy rain, even careful ploughing cannot prevent serious erosion.

It may not be possible to show the pupils examples of contour ploughing and other conservation practices near the school in urban and suburban areas. More dependence must be placed on pictures, slides, and films. However, there may be possibilities that are unsuspected by the average person. Contact the local agricultural agent and see if he has suggestions for worth-while trips.

### Pages 50–51

These contrasting pages in cartoon style show the effects of good and bad practices on a region from the standpoint of the land owner, the sportsman, and the traveller. It should point out that conservation is a problem for all of us, not for land owners alone.

Pupils may like to make charts and models based on similar themes. Dioramas in cardboard cartons may show a region before and after a forest fire, the effects of over-grazing, how gullies can be checked, and related topics.

### Page 52

Wind erosion is a problem in certain regions where land is left bare during extended periods as in "dry-farming" regions and in sections where droughts are attended by high winds. Wind erosion can be prevented only by keeping a cover of vegetation on the soil. This may be demonstrated by putting soil in a tray or pan, letting it dry, and then turning an electric fan on it. For comparison, use wet soil and soil covered by sod.

### Summary Questions

1. Topsoil is the darker coloured layer of soil that lies at the surface of the land.

2. Subsoil becomes topsoil when plants and other organisms penetrate it, loosening it and distributing humus through it. Man can do the same thing by ploughing under organic matter.

3. Topsoil is lost by stream action, by splashing, and by wind. This occurs when the soil is bare of vegetation.

4. Grass fires and forest fires kill vegetation that protects the soil, they burn dead plant materials that protect the soil and serve as a source of humus, and they destroy some of the humus in the soil. Increased soil erosion results.

5. In contour ploughing, the furrows are level, the plough having followed level lines or contours along hillsides. Contour ploughing is used to reduce the run-off of rain water by trapping it in the furrows. It thus reduces soil erosion.

6. The most effective way for keeping topsoil on steep hillsides is by keeping it covered with vegetation. Grasses and other pasture plants are excellent where the soil can support them and where animals can graze. Trees may be used in other places.

7. Gullies can be checked by planting vines and shrubs in them, by dumping rocks and trash at the heads, and by using check dams if erosion is too rapid to be stopped by other means.

### Follow-up

Through the year there may be opportunities to observe gully erosion and sheet erosion even in urban areas. Each new excavation will show gullying and the effects of spattering after heavy rains. In rural areas, erosion of ploughed fields can be watched through the winter and early spring. If erosion control is practised, the pupils can observe its effectiveness.

Newspapers and magazines contain accounts of soil erosion, its significance to the country as a whole, and methods used in its control. Some of these articles are excellently illustrated. The pupils should read these articles, report on them, and make bulletin board displays of the pictures.

An exhibit dealing with soil conservation makes an interesting display at parents' nights, P.T.A. meetings, and science shows. Such exhibits are also appropriate at country fairs.

## POSSIBLE LEARNINGS

Topsoil is very important to us.
Topsoil is the first part of the soil lost by erosion.
Subsoil becomes topsoil very slowly.
Plants help to hold topsoil in place.
Topsoil should not be left bare on steep slopes.
Careful ploughing and cultivation can reduce the loss of topsoil.
Fires and over-grazing destroy the soil cover.
The loss of topsoil has bad effects on plants, animals, and on man.

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### Books

*Earth's Changing Surface.* Bertha Parker. Copp Clark: Toronto, 1942. 35 pages.

A brief description of the earth's changing surface.

*The Land Renewed: The Story of Soil Conservation.* Edward Graham and William Van Dersal. Oxford: Toronto, 1946. 109 pages.

Our land, its ills and cures.

*The Land We Live On.* Carroll Fenton. Doubleday: Toronto, 1944. 88 pages.

How land is changed by water, fire, dust storms, and men, and how it can be conserved.

### Films

*Seeds of Destruction.* Encyclopaedia Britannica Films. Ontario Department of Education: SG-44.

Visualizes what happens to the soil when improper lumbering and farming practices are used.

*Understanding Our Earth: Soil.* Coronet.

The nature of soil, how it is made, and why it should be conserved.

SG-31 *Wearing Away of the Land.* Ontario Department of Education.

Demonstrates how natural forces are at work changing the physical features of the earth. Erosion by chemical decomposition, glaciation, wind and waves is shown.

# Time and Seasons

## PURPOSE OF THE UNIT

The astronomy sequence in the Exploring Science Series is based chiefly upon observational material. Theories about the motions of these bodies are referred to briefly, but the emphasis is upon what children can see for themselves. It is thus that astronomy is made real and meaningful rather than remote and abstract.

This culminating unit of the sequence lends itself especially well to this direct experience approach. The determination of time and seasons depends upon observations of the "apparent" motions of the sun, moon, and stars. Pupils can see for themselves the basis for our common units of time. Knowledge of theories about real motions of the heavenly bodies can supplement facts acquired this way but should never be a substitute for them.

The study of astronomy gives excellent opportunities for pupils to learn the difference between theories and facts. We should take advantage of these opportunities. For example, pupils may be shown photographs taken at high altitudes to indicate the curvature of the earth. Here are facts, facts that the earth is curved. But that earth is a sphere is a theory, because no one yet has seen the earth as a whole. The pupils may discover by further reading some of the facts that lead to the theory, and they may try to propose alternate theories. It is thus that pupils are helped to develop a scientific attitude towards much that is presented to them.

## PREPARING FOR THE UNIT

If this unit is taught in the fall, observations of seasonal changes can be continued through the remainder of the school year. However, it is recommended that the study of time be deferred until daylight saving is no longer in effect so that this complicating factor is removed.

Few materials are called for specifically although many things will help to enrich the unit. Several clocks are called for in the study of time zones; these are used for a few days only and may be borrowed for the occasion. Maps and globes showing the time zones are desirable. A number of globes of different sizes can be used to help to explain modern theories of the motions of the earth.

It is interesting to see a sundial and to compare it with a clock. Perhaps there is one near the school that may be visited. A twenty-four-hour clock or watch may also be available. Weather maps in local newspapers or from the Weather Bureau should be provided for a few days and if interest warrants, for several weeks or months. An almanac will give information about times of sunrise, sunset, and phases of the moon.

**List of Materials**

Long stick
Stakes
Hammer
Almanac
Calendar
Map of Canada with time zones
Weather maps
Globe
Clocks (several)
Flashlight
Mailing tube
Pans
Electric lamp and cord
Small globe or apple with wire standard

## TEACHING THE UNIT

A unit of this type should be extremely flexible to permit observations at any time during the year. It is recommended that the study of seasonal changes be started at the beginning of the school year and be ended when school is out in the spring. Special note should be taken of such special days as the solstices and the equinoxes. The ending and the beginning of daylight saving time should be discussed briefly. As news events and special radio programmes refer to differences in time round the earth, these points should be brought to the attention of the children. It is not always necessary to go into detailed explanations of such phenomena at the time, but the experiences can be referred to during more formal study of the unit.

Encourage the pupils to keep records of their observations. Often simple charts are sufficient but many times colourful and novel forms of record-keeping hold interest longer. When possible, have the pupils collect data before the unit is studied formally, and then encourage them to continue to keep their records to check on the material given in the textbook.

**Page 53**

This title page suggests an interesting experience. Watches and sundials rarely agree, and several questions immediately arise. The partial answer to these questions is a discussion of the nature of the two kinds of time involved. One depends upon the motion of the sun across the sky. The other depends upon artificial timekeepers, upon communication by radio or telegraph, and upon the work of astronomers. The former is slightly irregular; the latter is corrected to make it uniform. The former is for the specific locality of the sundial; the latter is for a large section of the country. Some of the questions will be answered by later work of the unit. The distinction to be made at this time is between time based on natural movements of heavenly bodies and time based on the movement of clocks.

**Pages 54–55**

Shadow study has been suggested in an earlier unit "Night Comes" for the fourth grade, but some of the experiences bear repeating, and all of them can be broadened to fit the higher maturity level. Encourage the pupils to note the position of the sun at several times during the day. Then occasionally cover the schoolroom clock and ask the pupils to guess the time. If this practice is continued through the year, pupils will learn much about the seasonal variation of the sun's path and will become proficient in estimating time by the sun.

The pupils may wish to make a sundial. They should experiment first with a shadow stick like the one suggested on page 55. If it is impossible to set up and maintain an experiment like this, a miniature shadow stick can be constructed by driving a nail through a thin board. The shadow of the point of the nail can be watched and its position marked at the end of each hour for a day. An alarm clock is helpful in reminding the class of the time to make records.

The shadow stick will serve as a timekeeper for a few days, but soon it will begin to vary from the clock. The pupils will then notice that the shadow stick of a sundial slants. Reference to encyclopedias and books that tell how to make sundials will tell the pupils how to make the shadow stick for their locality. They will have to mark on the hours to agree with the clock because the geometrical determination of these points is extremely complex. However, their sundial will give approximate time.

**Pages 56–59**

When teaching the rotation of the earth, do not depend upon globes and other models alone. Take the pupils outdoors and give them an opportunity to sense what is meant by rotation. Ask them to point at the western horizon and imagine the horizon tilting upward towards the sun, which is standing still. At the same time the eastern horizon is moving downward. At first the idea of a "tipped" earth will confuse them, and when they think of being "upside down" at midnight, they will be reluctant to accept the theory. But this is the theory, and this is the only way for them to really understand it. Models fail to give the picture completely.

Measurement of the day is not quite so simple as is described here. The day, as determined by one rotation of the earth, is slightly too long for practical purposes, and the day, as measured from noon to noon, is a little too irregular to be used with clocks. Astronomers determine the day as one rotation of the earth and shorten it by about four minutes to agree more closely with the day that is measured from noon to noon. These points are too complex for the pupils to deal with, but the question of the work of the astronomers might arise, and interested pupils can be referred to books about this matter of standardization of time.

The study of the motion of the earth round the sun should again be given as much reality as possible by taking the pupils outdoors and asking them to imagine the earth moving in a circle about the sun. In six months the earth would be on the other side of the sun and about as far away as it is at present.

In studying "leap year," it is helpful to have calendars of four or more consecutive years. Then the Februarys of these years can be compared and the addition of the extra day noted. The pupils also like to know how to determine leap years.

Our present calendar months are purely artificial. There was once a time when months were based solely on the phases of the moon, but the additional days left in each year caused so many problems that lunar time was abandoned. The present irregular distribution of days in the months is without astronomical significance. If the reasons for the change of phases of the moon are not understood, refer to unit seven in Book Five, "The Winter Sky."

Some of the pupils may be interested in attempts to modernize the calendar. One method uses thirteen months of four weeks each with a New Year's Day, and adds a Leap Year Day every four years. Another method divides the year into quarters, each having one month of 31 days and two months of 30 days each. A New Year's Day and a Leap Year Day are added. Both of these calendars have several advantages, including the fact that holidays and other special days always come on the same day of the week year after year.

**Pages 60–61**

Most of us take the clock face so much for granted that we do not consider its origin and we ignore its limitation. The twelve-hour-clock face was fairly satisfactory for a simple society, but it is badly outmoded in a society that is almost as active at night as in the daytime. The armed forces found the shift to the twenty-four-hour clock comparatively easy, and many serious problems were solved by it. By teaching our pupils its advantages, we may hasten the day of its adoption.

It would be especially helpful if a twenty-four-hour clock were available for a few days. However, the suggestion for making a face with movable hands will give the pupils practice in reading this type of face.

**Pages 62–63**

Radio and television programmes have made many pupils conscious of differences in time over the country and to some extent over the world. The diagrams on this page will help them to understand the reasons for differences in time, but many other devices should be used if possible. A flashlight or spotlight may be held near a rotating globe to show why noon comes at different times over the earth. Some globes are equipped with a ring like that shown on page 63; if not, a similar ring may be made of cardboard. This ring is helpful in understanding how to estimate time over the earth.

**Pages 64–65**

Standard time, first proposed by a Canadian, named Sir Sandford Fleming, can be introduced by reference to radio and television programmes. Frequently newspaper accounts mention standard time. The need for standard time is best understood by imagining the confusion that would result to travellers if each community along a railroad or a main highway had its own time.

Maps and globes often show the time belts into which the earth is divided. The reason for the irregular boundaries of these belts should be considered; study of one boundary in some detail will show how state lines are followed and large communities usually avoided.

Try, if possible, to keep a number of clocks set for standard time in parts of the world where important events are taking place. Pupils become conscious of both the events and the time involved, and they have a deeper sense of reality.

**Pages 66–69**

Depend upon first-hand observations as much as possible for data involving seasonal variation in the path of the sun. It is well to begin these observations in September and follow them through for two or three months before beginning to draw conclusions. Then this data may be supplemented by reference to almanacs for more precise data and for extensions into future months. The pupils may organize the data in various ways; a bar graph is shown on page 69. They may also use a curved line graph for the length of day or night. They may also organize the data in simple tables if graphs are beyond their understanding.

### Pages 70–71

Pupils usually understand the effect of changed hours of sunlight on earth temperatures, but they do not see so readily how the change in the sun's elevation can result in changed temperatures. First, however, it is necessary to establish the understanding that the elevation of the sun in the sky does change. This is done most simply by shadow study. The pupils should begin marking shadows in September and continue their observations through the year, always marking the shadows at the same time each day. Outdoors they may mark the end of the shadow of the flagpole or a building or a stick driven into the ground for this purpose. Indoors they may mark the borders of the spot of sunlight coming through a window. The latter activity can be especially effective in showing how the sunlight is "thinned out" in the winter months. For exhibition purposes, the records of shadows and areas of sunlight can be made on large sheets of wrapping paper, one for each observation.

The demonstration on page 71 helps to explain why sunlight is not so bright when it falls slantingly on a surface as when it falls directly. Reference to past experience should be used to broaden this demonstration. Pupils usually recall that early morning and late afternoon sunlight is not so warm as midday sunlight, and they may recall that summer sunlight at noon is hotter than November sunlight at noon.

### Pages 72–73

Weather is the result of unequal heating of the earth's surface, but the mechanics of weather changes are complex and poorly understood. At this level, it seems best not to go deeply into the causes for weather. The simple experiment suggested here should help pupils to realize that both soil and water warm up slowly and cool off slowly. They should then be able to understand why the warmest time of day usually comes in the afternoon, and why the coldest weeks are those that follow the shortest day. When they also realize that masses of air detach themselves and move across the country, they can also understand some of the marked variations in our weather.

The weather maps given in daily papers are fairly simple to understand, and pupils should be able to visualize the moving air masses represented on them. It is not necessary that they understand all the details of these maps nor should they be forced to study the maps carefully. Rather, it is better to mark an air mass, such as one originating in northern or western Canada, and watch its progress on a series of maps. When the mass crosses the region in which the pupils live, they can relate the map directly to their own weather.

### Pages 74–75

Only two pages are given here to a consideration of the effects of seasonal change on plants and animals. This is because the preceding books of the Exploring Science Series have devoted so much attention to this topic. However, these two pages may be extended and broadened to the status of another unit if the background and the interests of the pupils so warrant. It may be a topic that is carried through the year from early fall until school is out in the spring. It may deal with material already treated in earlier books, but given broadened meanings at this time. It may deal with totally new materials if local resources are sufficiently rich.

### Pages 76–80

The theoretical bases for the changes in the apparent motion of the sun in the sky are not easy to understand, and many pupils will not grasp them readily. It is recommended that the demonstrations suggested here be carried out and discussed without insistence upon complete mastery of the concepts. Some pupils will grasp the ideas quickly. Some will grasp them slowly but successfully. Some might grasp them if the topic were studied long enough but at the risk of boring many pupils. Some may not be able to understand this theoretical material at all. If the first-hand experience background suggested on the earlier pages has been established soundly, failure to grasp the theories represents no tragedy.

There are many possible ways for demonstrating the theories about the changes in the apparent sun's path. Diagrams and two different models are used here. Use as many others as time and interest permit.

#### Summary Questions

1. The spinning of the earth gives us day and night, according to commonly-accepted theories.

2. An hour is one twenty-fourth of a day.

3. Noon comes at different times in different places because the earth is turning. This brings sunrise, noon, or sunset to places in the east before places in the west.

4. Standard time is the time accepted by the people in different belts or segments of the earth's surface as being the same in all parts of that belt.

5. Summers are warmer than winters because the hours of sunlight are longer and because the sun shines more directly upon the land and water.

6. Seasons change because the sun's apparent path in the sky changes, it being higher and longer during the summer months than in the winter months. The cause of the changed path is believed to be the circling of the earth round the sun combined with the slant of the earth's axis during this movement.

7. The pupils may name those plants and animals referred to in this unit together with others with which they have had experience.

**Follow-up**

This unit needs extensive follow-up to make it effective. The observations of the sun's path, of shadows, and of changes in plants and animals should certainly be continued through the remainder of the school year. There will also be ample opportunities to call attention to variations in time while studying events that take place in other parts of the world.

## POSSIBLE LEARNINGS

The units of time are determined by man but are based on the apparent motions of the sun, moon, and stars.

Standard time has been established to eliminate confusions that would result if each community determined its own time.

The sun's path through the sky changes through the year.

The sun gives more heat to land, water, and air when its path is longer and higher in the sky.

The change in the sun's path is believed to be due to the revolution of the earth about the sun combined with an inclination of the earth's axis.

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### Books

*Stars.* Herbert Zim and Robert Baker. Musson: Toronto, 1951. 157 pages.

Excellent for teacher's background. Will interest the more able students.

*Story of Our Calendar.* Helene Carter. Copp Clark: Toronto, 1949. 63 pages.

Extends understandings developed in text.

*Sun, Moon, and Stars.* William Skilling and Robert Richardson. McGraw-Hill: Toronto, 1946. 274 pages.

An excellent book for the more able students and a good teacher's reference.

*Worlds in the Sky.* Carroll and Mildred Fenton. Doubleday: Toronto, 1950. 96 pages.

Begins with the earth and its movements which control our daily lives. Illustrated.

**Films**

*Seasonal Changes in Trees.* Coronet. Ontario Department of Education: SN-97.

The story of the seasonal changes in trees compressed into a few minutes.

*Seasons of the Year.* Coronet. Ontario Department of Education: SS-291.

Unfolds a full year of seasonal changes.

*Why the Seasons.* Society for Visual Education.

*Our Earth in Motion.* Jam Handy.

*The Earth as a Planet.* National Film Board.

# Our Eyes

## PURPOSE OF THE UNIT

This unit makes an important contribution to the area of safety and health. All pupils should develop a consciousness of situations that can result in injuries to their eyes and they should know of precautions that may prevent eye injury. Although the eyes of humans are amazingly well protected, each year there are many accidents that could easily have been avoided with a little forethought. And the ways of modern living result in practices that may weaken eyes.

The unit also makes a contribution to the area of anatomy and physiology. Throughout the Exploring Science Series there is material which helps children to better understand their own bodies. Previous units have dealt with the skeleton and the muscles, with the circulatory, digestive and respiratory systems, and with the senses of hearing and taste. Part of this material is used as a background for a better understanding of our eyes and the sense of vision.

The unit also reviews and builds upon previous material in the area of light. The fourth-grade unit "A Hand Lens" is of special help with the present unit.

The activities call attention to numerous, commonplace situations in which our eyes and other types of eyes are involved. Thus pupils become more conscious of things about them and their curiosity is aroused about many things they might never notice otherwise.

## PREPARING FOR THE UNIT

Few materials are essential for the success of this unit. A few magnifying lenses are needed for review and to teach new understandings concerning lenses and focusing. It is desirable that some of the lenses be comparatively thick (with a short focal length) and that some be comparatively thin (with a long focal length). Such lenses may be purchased, or they may be borrowed from a high school science department.

A bellows-type camera with a ground glass back is helpful in demonstrating that nearby objects may not be in focus when distant objects are in focus, and vice versa.

A model of the eye is useful, because it helps pupils to visualize the eye in three dimensions. Diagrams in two dimensions cannot be interpreted readily by many pupils. Charts are also useful but not so valuable as models. Charts and models may be borrowed from many high school science departments.

During the study of good home lighting, it may be possible to visit a store that sells many types of lighting equipment. The different devices may be demonstrated and their advantages described.

Health teachers sometimes have light meters that indicate whether the light in a place is adequate for good vision. Try to borrow one of these meters and test the light in a number of places.

A school doctor or nurse may be willing to visit the class and talk about proper eye care. They may also demonstrate such things as the way to remove dirt from the eye. Perhaps a visit to an oculist can also be arranged.

### List of Materials

Magnifying lenses of various focal lengths

## TEACHING THE UNIT

The work of the unit is based upon first-hand experiences. Try to give these first, and then lead the discussion into related fields where the pupils may recall past experiences and refer to books and pictures. Try to have some of the activities carried out in situations outside the classroom. A few possibilities for out-of-school experiences are suggested here, and others will suggest themselves. Many communities have special resources of which the teacher may take advantage.

According to the philosophy of this Series, technical language in the reading material has been held to a minimum. Only two special science terms are introduced in this unit, on page 83—"iris" and "pupil." However, many pupils will readily pick up other such words as "cornea" and "retina." Encourage them to do so, but do not demand that other pupils master such terms. Basic understandings are more important than words, and the understandings should always precede attempts to master the words.

**Page 81**

The title page should focus attention on eyes as the organs for seeing. Discussion may be guided to consider more in detail how we use our eyes for detecting danger, for finding food, for helping us make things, for determining how far away things are, for giving us pleasure. Consideration of the special problems of the blind and the ways they meet these problems can follow in as much detail as interest warrants.

**Pages 82–83**

Children usually know the outward structures of the eyes by their common names such as "eyelashes" and "eyelids." They may not know the terms "iris" and "pupil" as introduced here.

The colour of the iris seems to have no significance other than being an inherited characteristic. It is true that people who originated in regions of intense sunlight usually have brown eyes, and people who have blue eyes descended from stock that peopled more northern regions. It is dangerous to generalize on these facts, however, because eye colour may not have developed in response to a need.

Students may enjoy checking on the colours of the eyes of their parents and grandparents. Inheritance of eye colours is somewhat complex but pupils may begin collecting data and speculating about it.

As is mentioned in the text, the "pupil" is an opening in the centre of the iris. It is covered with the transparent layer known technically as the "cornea." The "pupil" is important because through it passes the light that gives us our view of the world.

Children can see the parts of the eye best by looking at the eyes of their classmates or by looking at their own eyes in mirrors. They may make coloured and labelled drawings of what they see.

## Pages 84–85

The simple experiment described shows how the size of the pupil can be changed in many ways. The room may be darkened and then the lights turned on while the children observe each other's eyes or observe their own in mirrors. The children may also be sent, one at a time, into a dark closet for a few minutes. Then as each emerges he will note the momentary discomfort until his pupils close slightly. It is also possible to note a considerable difference in the size of the pupils when looking outdoors on a bright day and when looking into a partly darkened room.

The children will notice that the iris controls the size of the pupil. The iris can enlarge towards the centre, thus closing the pupil. It can also fold up on itself towards the outside, thus opening the pupil. The iris serves to control the amount of light entering the eye. It helps to prevent too intense a light from entering and causing discomfort or damage to the light-sensitive surfaces within. When the light is dim, the iris allows a maximum amount of light to enter.

A camera usually has an iris to control the amount of light which enters it. If possible, demonstrate the iris of a camera. Take the back from the camera, set the shutter on "Time" and open it, and look through the lens while adjusting the iris.

Children have usually had numerous experiences with the discomfort caused by sudden bright lights, and they may have noticed the gradual adjustment of their eyes when they move from a bright place to a dim place. Let them describe these experiences.

## Pages 86–87

Our eyes are well protected against being bruised by large objects that may hit them. Children will quickly discover the bony ring that surrounds each eye. Have them notice how difficult it is for a large object to exert any pressure on the eyeball. If possible, show them a human skull at this time. Most mammal skulls show how the skull protects the eye sockets.

Children should be extremely conscious of the dangers involved in the acts listed on page 87. They should know that sharp objects should be pointed away from the person to whom they are being handed. They should know that a knife should cut away from the user, whether used for cutting string or for cutting wood. Matches, too, should be scratched away from the user lest bits of flaming sulphur fly into his eyes. As for pretending to fight with sticks and running with a stick in the hand, it should not be done. The children will probably suggest other safety practices, such as wearing a catcher's mask when playing baseball and goggles when using a grinding wheel. Encourage them to list numerous safety rules. The rules may be put on a chart, or each rule may be illustrated with a poster.

### Pages 88–89

Our eyelids serve to keep out most of the tiny particles that might strike the eyeballs. Help the pupils to understand something of the involuntary nature of blinking. Pupils should begin early to build up an experience background dealing with human behaviour. They may name other involuntary acts such as breathing, heart beats, swallowing, coughing, and vomiting. The response of the iris to light intensity is another. Later in this unit the pupils will learn about focusing of the lenses in the eyes and about the response of the two eyes to things nearby and far away. Call their attention to the involuntary nature of these acts.

The effectiveness of the eyebrows in keeping sweat from the eyes is somewhat doubtful, although they do serve this purpose to some extent. Possibly eyebrows today are something we inherit like eye colours, but there may have been a time when they were very useful. Eyelashes certainly are effective screens for much of the small material that is blown towards the eyes. The trick of nearly closing the eyes until the eyelashes intermesh is well known by outdoorsmen.

### Page 90

Tears lubricate the eyeball and keep the exposed surface from drying out. They also help to wash out dust that settles on the eyeball. Few people realize that tears flow continuously. The tears are produced in small quantities that move across the eyeballs, enter the nose, and evaporate before they make themselves conspicuous. Irritation of the eyes, such as particles under the eyelids, or infections, cause large discharges of tears from the glands. Interestingly enough, the tear glands are stimulated by certain emotions such as sorrow and pleasure. The children will probably enjoy discussing this aspect of the eyes. The discharge of tears and the blinking that spreads them over the eyes are both reflex acts.

### Page 91

Try to have a doctor, a nurse, or a first-aid specialist talk to the class about the care of the eyes. Perhaps they will demonstrate the proper methods for removal of particles from the eye. A first-aid handbook should be made available to the class, and everyone should be encouraged to read the section on treatment of eye injuries.

**Pages 92–93**

The eyeball is much larger than its external nature indicates. A model is especially valuable at this time to give the pupils some indication of the respective sizes of the various parts. On a sheet of cardboard draw a face to the same scale as the model eye, and cut out the space between the eyelids of one eye. Set the model eye at the edge of a table and hold the cardboard in front of the model so that the pupils and iris show through the opening in the face. This helps children to see the relation between the part of the eyeball that can be seen and the remainder of the eyeball.

Direct the children to move their eyes and to notice other people's eyes moving. Have them discover the range in which they can see things without moving their heads.

Ask them to observe their pets and find out which ones can move their eyes as people do.

Observing things with two eyes, binocular vision, is interesting because of the involuntary nature of the movement of the eyeballs. As objects at decreasing distances are examined, muscles turn the eyeballs toward each other. At extremely close ranges the eyes are "crossed." For short distances, within an arm's length or slightly beyond, binocular vision helps us to determine the distance to an object, but it is doubtful if it helps at distances of a hundred feet or more.

**Pages 94–95**

Most eye models are dissectible and show the shape and location of the lens. A model will give a much better understanding of the structure of the eye than two-dimensional diagrams can give.

Glass lenses can be used to demonstrate the function of the lens in the eye. First is the projection of an image by a magnifying lens. In the eye, the lens produces an image on the retina (which is the back surface of the eye) where there are numerous light-sensitive nerves. Pupils may wonder why we do not see everything upside down as the image must be on the retina. Explain that our brains make the necessary adjustment so that we see things right side up.

Glass lenses can also show the effect of the relative thickness of a lens on the formation of images of nearby and distant objects. If a focusing camera with a ground glass back is available, this may be used to show that with a lens of a certain thickness, some objects will be in focus while others are not. Set the shutter of the camera on "Time" and open the shutter. Open the iris wide. Focus the camera on the window-sash and note that the landscape beyond is not in focus. Focus on the landscape, and the sash is not in focus.

The lens in the eye cannot be moved back and forth like the lens in a camera. Instead the thickness of the lens is changed. The experiment suggested on page 95 shows the effect of using lenses of different thickness.

### Pages 96–97

Page 96 describes how the lens changes when a person looks at something nearby and far away. The experiment establishes the effect of the change. Many children will be able to feel the adjustment that takes place within the eye.

A large share of the cases of deficient vision are due to the inability of the lenses to change their shape sufficiently. The lenses of glasses help to compensate for these deficiencies. Students are not ready at this time to understand the nature of the lenses used in glasses, especially those used for near-sighted people. It is sufficient that students realize that glasses do compensate for many deficiencies of the lenses. They should also realize the advantage of glasses to people of poor vision.

### Pages 98–99

Although there may be some doubt about the harm that poor lighting does to the eyes, there is no doubt about its tiring effect. Children should realize that close work puts a greater strain on the eyes because the muscles of the lenses must be tense to keep the lenses thick. They should also know something of the light ranges that are considered adequate for good vision. If a "sight meter" is available, test a number of different places such as different parts of a classroom and places outdoors. Try to test some rooms lighted only by artificial light to see how poorly most of these rooms are lighted. If a "sight meter" is not available, use a photographic light meter in its place, considering that the light on the shaded side of a building on a sunny day is best for the eyes.

The class may make a study of direct and indirect lighting for homes at this time. If possible, show them many types of lighting devices. A store that sells these devices may be willing to demonstrate them to the class. Work out for the class the relative expense of using several electric lamps compared with one lamp.

### Pages 100–104

When we compare animals' eyes with our own, we can compare only the structures because we do not know exactly what an animal sees. We can guess that animals with eyes much like ours, such as the mammals, see things as we do. We know that some animals detect distant objects very well, and we know that others do not seem to identify things that are not in motion. The ability of different animals to detect colours is open to question.

These pages suggest some observations that students can make about animal eyes. The extent to which these suggestions may be amplified should depend upon resources for animal study and upon the experiences of the pupils. Zoos and museums present many possibilities for the study of the location of the eyes of animals. In some cases, the general appearance of the eyes can be observed.

Sometimes pets can be brought into the classroom and, by darkening the room, the effect of light on the pupils of pets' eyes can be studied. In making this study, experiment with fish and frogs as well as with rabbits and cats.

Large insects such as grasshoppers, dragonflies, and butterflies have compound eyes that are relatively very large. Perhaps living or preserved specimens of such insects can be studied.

### Summary Questions

1. Light enters the eye through the pupil. It then passes through the lens and goes to the back of the eye.

2. The lens in an eye has the shape of a magnifying lens, being thicker in the centre than round the edge.

3. Our eyes are protected by being set in hollows in the skull and having a ring of bone about each. We automatically try to ward off objects coming toward our eyes. Our eyelids shut as something moves rapidly toward our eyes.

4. As the light about us becomes brighter, the pupils of our eyes become smaller.

5. Reading and close work result in a strain on our eyes because the lens muscles must keep the lens thick so that we can see nearby things more clearly.

6. Children may list the rules they have formulated for the safety of the eyes and add other rules concerning reading and doing close work. They should also mention ways of preventing infections of the eyes, including what to do when dirt gets in the eyes and keeping unclean fingers from the eyes.

7. The creatures that see well at night vary from region to region, but the children will usually name cats, rabbits, owls, bats, and moths. They may name others according to their past experiences with such creatures.

### Follow-up

As children have eye examinations and perhaps are fitted with new glasses, there are opportunities for the children to describe their experiences and discuss the procedures. If possible, arrange for a trip to an oculist following a discussion of eye examinations.

There are always numerous occasions when the children's attention should be called to wise and unwise practices concerning their eyes. Sometimes suggestions for additions to the list of safety precautions arise from these situations.

As new animals are encountered through the year, consider briefly the eyes of these animals. Often unanswerable questions will be raised, but these questions may serve as a stimulus for further investigation in later years.

## POSSIBLE LEARNINGS

The amount of light entering our eyes is controlled by the iris.
Light entering the eyes is focused by a lens in each eye.
The lens in the eye focuses by becoming thicker or thinner.
Our eyes are well protected by bones, eyelids, and by automatic acts on our part.
Our eyes may be injured by small or sharp objects striking them.
Our eyes become tired if the lighting is improper.
The eyes of some animals are much like ours, but other animals have eyes that seem to be entirely different.

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How our eyes play tricks, demonstrated with activities and experiments.

*From Head to Foot, Our Bodies and How They Work.* Alex Novikoff. Progress: Toronto, 1946.

A book of facts that children want to know about themselves.

### Films

*Eyes-Elementary.* Encyclopaedia Britannica Films.

Photography and diagrams compare the eye and the camera.

*See Better: Healthy Eyes.* Coronet.
Why and how we should take care of our eyes.

*H-8 Eyes and Their Care.* Ontario Department of Education.
Information about the structure and care of the eyes.

# Making Work Easier

## PURPOSE OF THE UNIT

Our culture today is virtually a culture of machines. But not all machines are the complex monsters that haul our goods from place to place and whisk us over high mountains. The great majority of our machines are the simple devices we use around our homes in our daily lives—can openers, hammers, hoes, and jack-knives. Power shovels and derricks are but combinations of machines as simple as these.

People use tools more effectively when they understand the principles on which the tools are based. A person who knows where shears exert their maximum force is careful to put the object to be cut as near this position as possible. A person who knows how to reduce friction, applies this knowledge to save himself effort as well as wear on his machines.

A sequence dealing with machines is carefully developed in the Exploring Science Series. The simple pulley is introduced in the first-grade unit "Watching the Flag;" friction is considered in the second-grade unit "Moving Things More Easily;" energy is studied in the third-grade unit "Making Things Move;" levers are introduced in the fourth-grade unit "Balancing Forces;" and windlasses and pulleys are treated in the fifth-grade unit "Lifting Things." This unit deals with inclined planes, screws, pulleys, and levers.

The object of this unit is not to duplicate the mechanics section of a course in physics but to acquaint pupils with applications of simple machines. The principles studied are developed only for the specific applications. Big generalizations are deferred to later courses in science.

The activities suggested here permit pupils to manipulate and experiment. So much school work is based on reading and listening that important senses are neglected. An understanding of the lever action of a hammer used for pulling nails, for instance, is effectively understood only through muscular action—the kinesthetic sense. Pupils need many opportunities for learning in this way.

## PREPARING FOR THE UNIT

A unit that depends largely upon manipulation needs materials with which pupils can work. The more plentiful these materials, within reason, the richer the experiences the pupils can have.

Specifically called for by the unit are two wide boards of different lengths, perhaps six feet and ten feet respectively, two single pulleys often sold as "awning pulleys," and such miscellaneous materials as sticks, string, a hammer, a pair of metal shears, a gallon jar or round can, some large bolts, and some sand. Suggested as being desirable are a wheelbarrow and a jack-screw. The jack-screw may be borrowed from a building contractor or a garage. The wheelbarrow may be borrowed from a home gardener, from a contractor, or perhaps from the school maintenance staff.

Many additional materials that illustrate applications of machines will suggest themselves. Metal shears will suggest cloth shears, pliers, nutcrackers, and pruning shears. The jack-screw will suggest a vise, screw clamps, a meat chopper, and a wood auger.

Whenever possible, take the pupils to see common tools being used. The school shop has many examples. Minor construction and repair projects are usually carried out with simple tools. Study each tool separately, finding out what it does and what techniques are needed for using it, rather than merely discussing it in terms of general principles.

**List of Materials**

Wide boards of different lengths
Gallon jar or can with cover
Tape measure
Bolts and nuts
Sticks
Book end
String
Hammer
Nails
Wheelbarrow (if possible)
Metal shears
Awning pulleys
Boxes
Round sticks
Marbles
Jack-screw (if possible)

## TEACHING THE UNIT

As stated before, the purpose of this unit is not to duplicate the mechanics of a physics course. We want pupils to know how and why common tools are used. It is more important that pupils know how to apply the maximum force with a pair of shears than it is for them to recognize shears as a pair of levers and talk learnedly about fulcrums, effort arms, and resistance arms. It is more important that pupils know the advantage of using a gentle slope to raise a load than for them to be able to calculate mechanical advantages and velocity ratios.

The language of mechanics has little use at this level. Technical words often have but limited use, and they are usually narrowly applied. They represent a jargon that is useful to people who are specialists and who have developed necessary understandings. They are confusing and often disheartening to the beginner.

In this unit there are four science terms which it is felt have wide, general use, and which have therefore been given emphasis. "Jackscrew," "friction," "ball bearing," and "roller bearing" appear in boldface type as terms of the special science vocabulary introduced in Book Six. All but "ball bearing" (which occurs in Book Two) are new words at this level.

### Page 105

The title page shows a few methods that are used to make work easier. Some of the methods utilize machines with which the pupils are familiar, at least in principle. The derrick is such a machine. The tractor with its trailers is another. Some of the pupils may recognize the ship as still another.

The pupils may recognize the two-wheeled truck, patterned after a wheelbarrow, as reducing the friction that would result if the load were pushed across the dock. It is not likely that the pupils will recognize the gang-plank and the plank up which the man is rolling a barrel as important labour-saving devices.

Therefore the title page may well be used twice, at the beginning of the unit and at the end. At the beginning, after pupils have recognized some of the machines, they may suggest others within their experience. At the end, they may study the page to apply some of the learnings developed during the unit.

### Pages 106–107

These pages develop a principle that is behind many of our methods of making work easier. This principle is that of dividing the work into segments of convenient size and doing each one separately. These pages take note of the fact that this procedure also slows down the rate of doing work.

Pupils are accustomed to applying this principle without realizing it. They transport many things a bit at a time. They stop to rest during long climbs. They also see the principle applied by others in similar fashion.

They should be able to list many applications of the principle. The transportation of bricks and soil is noted here. They may have seen coal, firewood, wet concrete, water, vegetables, and lumber moved this way. Farm children will have seen feed, hay, fertilizer, and milk moved a bit at a time. Some children may have watched furniture movers carry a few things at a time, and some may have seen heavy objects taken apart so that the objects can be moved more easily.

### Pages 108–109

The use of a sloping surface, or "inclined plane" as it is often called, is another way of slowing down the rate of doing work. In a sense, it is the same as dividing up the work in segments and doing each bit in a longer time than would otherwise be possible. The experiment described on page 108 is especially effective if the object to be rolled up the board weighs at least ten pounds. A gallon jar or tin can of equivalent size will weigh this much if filled with sand. A larger can will be more effective.

Each pupil should have an opportunity to lift the can and then roll it up the long and short boards to the top of a box. It is only thus that each one can understand the forces involved in each situation. They will discover that the force needed to roll the can up the longer board is small compared with that needed to lift the can directly.

Variations on the experiment can be performed. A toy wagon can be loaded with stones and pulled up both a gently sloping plank and a steep plank. A small wheelbarrow can be pushed up the same planks.

Pupils will often see applications of this principle at various construction projects. Men push wheelbarrows and roll heavy pipes and other round objects up planks.

### Pages 110–111

Stairs and ramps are additional applications of the inclined plane. If stairs of different slopes can be studied, the pupils will be able to notice the difference in the force their legs must exert to lift them up the stairs. To compare stairs numerically, they should measure the vertical height of the stairway and the length of the stairway. Dividing the latter by the former gives the distance moved in climbing one foot straight up. They may make the same calculations for ramps.

Pupils will see ramps in several places. Ramps are used in hospitals to move operating tables and wheel chairs from one level to another, Ramps are used in garages to move cars from one floor level to another, and from the street level to the garage floor. Ramps are used in many factories. One or more ramps may be found in the school building.

### Pages 112–113

Paths, roads, and railroads that go diagonally up a slope, or wind up the slope, are extensions of the principle of the inclined plane. The greater the length of the slope the less the force that has to be applied to raise an object a given distance. If there is a steep bank near the school, carry out the experiment suggested on page 112. The children will grasp the understanding most quickly this way.

If there is a steep street that has little traffic on it, ask a pupil to demonstrate how the street can be climbed on a bicycle by zigzagging back and forth. If skiing is one of the sports of the region, pupils can describe how to climb long, open slopes with minimum effort.

Mountainous regions show applications of the inclined plane principle to roads and railroads. Look for these locally if possible. If not, use pictures to demonstrate the practice. In hilly, rural regions, pupils may also look for cow-paths on steep slopes as illustrations of the unconscious application of engineering principles by animals.

### Pages 114–115–116–117

The jack-screws (or screw-jack) is astonishingly effective for lifting heavy loads with a minimum of effort. Try to arrange for a demonstration of one. Building contractors usually have jack-screws, and many garages have them. The pupils will be amazed at how easy it is to raise a heavy car or a truck with one of these jacks. If they are able to measure the distance their hands must move in order to lift a load one inch, they will see how much the rate of doing work is slowed down.

That the thread of a screw is a winding ramp is not at first obvious, but the demonstration using the triangle of card wrapped about a pencil should help the pupils to see that it is. They should also follow the thread of several screws with a pin point or a pencil point, pretending that they are climbing the ramp. Then when they screw a nut on a bolt or tighten a vise, they will realize that the nut is climbing the ramp in each case.

### Pages 118–119–120–121

These pages show some simple ways to experiment with levers. Many variations are possible. The pupils will discover that the most effective place for the support is near the load as possible, and that the farther from this point the support is placed, the greater is the force needed to move the load. By measurement, they will discover that when the support is in the most effective position, the hand moves a long distance compared with the distance the load moves.

The hammer is a tool that utilizes this principle when it is pulling a nail. Drive a number of nails into a block of wood, and let the pupils experiment with the best places to put their hands on the handle of the hammer while pulling them out. They will discover that the hand is as far out on the handle as possible when the required force is least.

The support of the hammer is the place where its head touches the wood in which the nail is driven. As the nail comes out, this point of support moves away from the nail. It therefore becomes difficult to pull a long nail after the exposed part has become two or more inches long. Show the pupils how a block of wood under the hammer head puts the support back near the nail and makes it easier to finish pulling the nail.

### Page 122

Experiments with a wheelbarrow give the same results as the experiments with the hammer and the straight bars of wood. The most effective place for the load is as near the point of support as possible, and the most effective place for the hands is as far as from the point of support as possible. Permit every pupil to carry out the experiments.

### Page 123

Although shears, pliers, and related tools are pairs of levers acting together, it is better to consider them as a separate group of tools rather than as simple levers. Metal shears are especially suitable for experiments that establish the basic principles. The pupils will discover that the wire should be placed as near the pivot as possible, and the hands should be as far from it as possible. Other types of shears and pliers may then be studied to see if the same principles hold. Perhaps it will be possible to show the pupils a pair of bolt clippers that cut steel rods half an inch through. Garages and metal shops usually have bolt clippers and will demonstrate them to a class.

### Pages 124–125

Simple combinations of pulleys are introduced at this time so that pupils will have an opportunity to apply what they have learned about forces and distances to these easily-studied machines. Be sure to use substantial pulleys such as awning pulleys, strong cords, and heavy weights. It is thus that pupils get their best understandings of the forces involved.

Measurements of the distances involved can best be taken by marking the cord at the point where it leaves the pulley, pulling on the cord to raise the weight the required one foot, and then measuring the length of the cord that passed through the pulley.

### Pages 126–129

One of the simplest ways to make work easier in many situations is to reduce the friction that makes movement difficult. The two methods in common use are lubrication and the substitution of rolling friction for sliding friction.

Encourage the pupils to look about them for evidences of friction. Wherever one moving body rubs against another body, there is friction. In the classroom it may be found in door hinges, door knobs, and the doors, in the channels of sliding windows, in the axle of the pencil sharpener, in the hinges of desks, and the slides of the drawers. The pupils should be able to list numerous examples.

Besides performing the experiment which shows the effect of lubrication, the pupils can try lubricants on other surfaces. A desk drawer, for instance, slides more smoothly after it has been rubbed with soap. They may put oil on the bearings of roller skates. One pupil may show how to grease a bicycle. At a garage an attendant may be willing to show how a car is lubricated.

Ball bearings and roller bearings can be seen in roller skates, bicycles, and the wheel bearings of automobiles. It is sometimes possible to get worn specimens of bearings at garages or bicycle repair shops.

See pages 139–141 of *Exploring Science Two* for instructions for making a simple ball bearing.

### Page 130

Pupils today usually know some of these uses for the energy in gasoline. Some of the pupils may wish to include other petroleum oils with gasoline so that they can add diesel-powered machines to the list.

The energy of coal is still used to propel ships and locomotives, but it is being displaced by the energy from petroleum. Coal is still used to drive machinery in factories, and it is also used increasingly to produce electrical energy.

The energy of falling water is today used almost exclusively for the production of electrical energy. Pupils should be able to tell a little about the process and tell how the electrical energy is distributed.

#### Summary Questions

1. If a road winds up a mountain, it is possible to make the climb longer, thus slowing down the rate of working.
2. A jack-screw slows down the speed of doing work. A person must move through a long distance to raise a load a short distance with a jack-screw.

3. Probably the simplest way to raise a heavy barrel into a truck is to roll it up a long plank. Other ways are pulley systems or derricks.

4. The farther the hands are from the pivot of a pair of shears, the greater the cutting force of the shears. Metal shears need long handles because much force is needed to cut metal. Cloth shears can have short handles because the cutting force need not be large.

5. The best place for the support of a lever is as close to the load as it can be placed if a very heavy load must be raised.

6. Oil and grease reduce friction and cause automobiles to move more easily. Oil and grease also reduce wear of moving parts.

7. To move a heavy box across the floor more easily, put rollers under it.

### Follow-up

As applications of the principles and the types of tools studied here are encountered, a few minutes should be taken to call them to the attention of the pupils and discuss them. Frequently these things are seen on trips that have other purposes. Sometimes, too, it would not be worth while to take a trip to see a single application of a machine, but a trip with several objectives would be effective. It is not necessary that all the applications be studied at the time the unit is taken up.

## POSSIBLE LEARNINGS

Sometimes we can do work more easily by dividing it into small parts and doing a part at a time.

Sometimes we can make work easier by slowing down the rate at which we work.

We can usually make work easier by reducing friction.

Slopes and ramps make it easier to raise things because less force is needed.

For raising a heavy load, a lever is most effective when the support is close to the load and the force applied is as far from the support as possible.

Screws and pulleys are used to slow down the rate of doing work.

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A source of additional activities.

*How Things Work.* Creighton Peet. Clarke, Irwin: Toronto: 1941. 115 pages.

Interesting information about elementary mechanics.

*Let's Find Out.* Herman and Nina Schneider. S. J. Reginald Saunders: Toronto, 1946. 38 pages.

Air, heat, weather—a picture science book.

*Now Try This.* Herman and Nina Schneider. S. J. Reginald Saunders: Toronto, 1947. 40 pages.

Contains simple experiments on work and friction, levers and wheels.

# Musical Sounds

## PURPOSE OF THE UNIT

The content of this unit is designed to give pupils an understanding of the cause of sounds and the factors that control the pitch of sounds in some of the more familiar musical instruments. Some attention is given to the mechanics of the human voice and hearing. The unit builds specifically upon the third-grade unit "Hearing Sounds" which emphasizes the transmission of sound.

This is a "do" unit with many suggestions for experiments, for the study of musical instruments, and for projects. Pupils have opportunities to learn through first-hand experiences, to develop co-ordination and skills with tools, and to plan and organize group projects.

The scope of the material is sufficiently wide to touch upon many interests, and the approach used serves to strengthen and broaden these interests. Thus a child with an interest in cowboy music played on a guitar may discover that violins are interesting, too. A child who has made a whistle may wish to play a wind instrument. Such broadening of interests is a measure of the success of the science programme.

## PREPARING FOR THE UNIT

It is well to assemble most of the materials called for by the experiments suggested in this unit in advance of introducing the unit. Project materials will depend much upon the interests of the pupils but some of the stock materials can be provided in advance.

The tools needed include such common items as hammers, screwdrivers, pliers, a hand-saw, and a brace with bit for boring holes.

Lumber, preferably a soft wood such as white pine, is needed. It should be between half an inch and one inch in thickness and in assorted lengths.

Hardware should include assorted sizes of round-head screws, nails, screw eyes, and some flat-head stove bolts an inch long.

The most satisfactory strings for the homemade instruments and for some of the experiments are steel strings. A set of guitar strings provides a good variety of sizes. As pupils carry out their projects, they may wish to buy other types such as violin and banjo strings.

Pupils can whittle out keys and bridges but violin keys and bridges are not expensive. They may be purchased in music stores together with the strings. Other bridges may be used.

One or more tuning-forks are desirable. These can be purchased from many music stores or from science apparatus supply houses. Sometimes they can be borrowed from school science departments. Try to get forks of different pitch.

There are many toy musical instruments on the market. Some of these toys illustrate the principles developed in this unit. They may be purchased. Many may also be loaned or given to the class by pupils who no longer play with them.

If the school has a music department with an orchestra and a band, the problem of showing the pupils professional musical instruments will be simplified. Otherwise, one must contact people in the community who can and will demonstrate such instruments to the pupils. Music stores may be helpful.

Most schools have a small record player that can be used in the study of stored sounds. Use inexpensive or discarded records for experiments and for the pupils to examine with a hand lens. Some schools have a record-making machine which can be demonstrated.

In the study of the voice box and the ear, models and charts are helpful. Borrow them from the science department of the school system.

In this unit there are three special science words. "Vibrates," "pitch," and "reeds" have been set in bold-face type the first time they occur in the text.

**List of Materials**

Nail files or hack-saw blades
Tuning-forks
Board
Guitar or other wire strings
Tin cans
Copper wire
Screws and screw eyes
Nails and string
Broomsticks or other hardwood
Rubber balloon

Stove bolts
Drinking glasses
Bottles
Record and player
Hand lenses
Card
Needle or pin
Brass paper staples
Funnel
Whistles, musical toys, and musical instruments as available
Tools: hammers, pliers, screwdrivers, hand-saw, brace and bit

## TEACHING THE UNIT

**Page 131**

The picture of the orchestra and the chorus suggests some ways that musical sounds are made. The pupils may make lists of sources of musical sounds beginning with those illustrated and adding others from their experience. They usually know about such instruments as guitars and pipe organs. They may know about calliopes and hurdy-gurdies. Some may suggest birds. Many pupils will be interested in reading in encyclopedias about some of the unusual instruments.

**Pages 132–133**

Instead of the nail file suggested on page 132, one may use any flexible strip of metal. Hack-saw blades are excellent.

The wire used in the next experiment may be of any metal, but a steel guitar or violin string is desirable. A table fork can be substituted for the tuning-fork but is not so satisfactory.

As the unit progresses, give the pupils other opportunities to touch objects that are giving off sounds. Radios, phonographs, violins, guitars, and similar instruments give off notes of low enough pitch for the fingers to detect vibrations.

**Pages 134–135**

Most pupils are able to detect a change in pitch but many cannot determine whether the change is up or down, especially if they have had little training in music. It may be well to let the pupils practise determining the type of change. Scales may be sung or played up and down on a piano. Pupils should tell which way the scales go. Then two notes of different pitch may be sung or played, and pupils should indicate which is higher or lower.

**Pages 136–137**

The apparatus described here should present no difficulties in construction. To start the screw eyes, make small holes in the proper places with a nail and then press the screw eyes in the holes before turning them. The bridges may be any small pieces of wood, preferably hardwood.

The pupils should summarize their discoveries somewhat as follows:

1) Shortening the vibrating part of the string raises the pitch.
2) Tightening the string raises the pitch.
3) A thin string has a higher pitch than a thick one if the length and tightness are the same.

## Pages 138–139

Many pupils are acquainted with the guitar, and this instrument is good for the introduction of stringed instruments. However, other instruments, such as the banjo, may be used. It is usually possible to borrow one for the occasion. Show the pupils how to tune the strings. Let them feel the strings to notice the difference in diameters. Let them pluck a string to produce a note. Then show them how the string is shortened to change the pitch. A teacher need not be able to play the instrument to demonstrate these things.

If the school has an orchestra, it will be possible to show the pupils the members of the violin family. Otherwise, it may be necessary to use pictures. In most communities, however, there is someone who plays a violin and who may be willing to demonstrate it.

## Pages 140–141

The cigar box guitar described here has a surprisingly good tone. Many pupils will quickly learn to play simple tunes on it. The method of construction shown here is satisfactory for a one-string guitar, but the cigar box is usually not strong enough for use with four strings.

The violin described here is strong enough to support four strings if the pupils wish to make a more elaborate instrument. It is also possible to make instruments of different sizes to represent bass viols, cellos, and violas, if desired.

Positions for the fingers may be marked on the necks of both guitars and violins. The instrument should first be tuned with a piano and then the desired notes struck on the piano to find finger position.

## Pages 142–143

The two panels in the front of an upright piano slip out easily; usually you lift the panel slightly and pull it forward. The mechanism may then be seen. Call attention to the length and thickness of the different strings. Show the pupils the pegs on which the upper ends of the strings are wound. These pegs are turned to tune the piano.

The pupils should be allowed to strike a few notes so that they can see the hammers strike the strings. They should notice the damper action at the same time so that they can see that a string vibrates while a key is held down, but that the damper stops the vibrations as soon as the key is released.

Many pupils may not have seen a harp but most of them have heard of harps. Large concert harps have strings much like piano strings in that there are many strings of varying lengths, tensions, and diameters. The strings are played by plucking rather than by striking.

In the harp that the pupils make, the longest string should be at least two feet long. Steel guitar strings may be used. There should be at least eight strings to give the simple scale; thirteen strings will include half-tones and make it easier to pick out simple melodies.

If possible, take the pupils to see a concert harp being played. There may be other types of harps available. An interesting form called the "autoharp" was once common and may still be found occasionally.

**Pages 144–145**

If pupils cannot study a real xylophone, one of them can probably bring in a toy xylophone. There are many toys that use the same principle, having bars of wood or steel. Toy pianos often have metal bars instead of strings. Music boxes have metal bars that are plucked rather than struck. Show pupils these devices if possible.

Musical glasses are fun for pupils to experiment with. A simple procedure is to select eight glasses or bottles of the same kind and tune them to the notes of the scale. Five additional ones can be used to give the half-notes. It is also possible to use glasses or bottles of different sizes and shapes. These should be arranged so that they approximate the scale and then they should be tuned.

**Page 146**

The reeds of a mouth organ, also called a harmonica, can be seen by prying off the side covers of a discarded or inexpensive model.

If possible demonstrate an accordion to the pupils. They will be interested in how the notes are produced and how the air is compressed in the bellows. Another reed instrument that was well known fifty years ago but is decreasingly common today is the reed organ. It may be possible to show pupils one of these.

A number of toy musical instruments use reeds. Some noise makers have single reeds. Toy accordions may play one or two octaves.

### Pages 147–148–149

It is not possible to demonstrate to the pupils with any simple materials the vibration of an air column in whistles and similar instruments. The pupils must take this on faith. However, they can see from an experiment such as that on page 147, that changing the length of an air column does change the pitch of the sound given off. This helps them to accept the concept of the vibrating air column.

After the pupils have tuned a set of bottles to play a scale, they may play simple melodies on them, picking up first one bottle and then another. A pipes-of-pan can be improvised with test tubes in a test-tube holder, tuning the test tubes with water.

Some kinds of whistles resemble the bottle whistle closely. One of these has a metal mouthpiece that blows across the opening in a metal chamber. Referees and scout leaders often use this kind of whistle.

The whistle shown on page 148 is a common type. In rural areas such whistles are often made from willow or maple twigs. Steam whistles on boats and locomotives are usually of this type. Pupils can make them with any hollow tubing such as bamboo or even of pipe, Rollers on some window-shades are hollow and can be used.

Whistles with variable pitch such as those on page 149 are common toys. Pupils should be able to bring several kinds to school for study. Toy fifes operate on the principle of the whistle, as do ocarinas. A popular instrument called the recorder is a type of whistle.

Discourage pupils from putting to their mouths instruments others have played. Use a solution of alcohol prepared by the health department, or strong soap and water, to disinfect them.

### Pages 150–151–152–153

The amount that can be done in the study of wind instruments depends upon facilities. A school with a large band or orchestra usually has these instruments in the building; one may make arrangements with the leader for demonstrations. Music teachers will often cooperate in demonstrating various instruments. They usually have recordings that illustrate the range and quality of the instruments.

A local music store may also have several kinds of instruments on display which the owner may be willing to demonstrate.

Ask for old catalogues of musical instruments. The pictures may be cut out and made into posters to illustrate principles in this unit.

### Pages 154–155

For this experiment it is well to use an old record that is not considered valuable. There are a number of ways of producing a sound from the record. One method using a horn is shown. A needle may also be inserted in the corner of a card and held to the record. The card will vibrate and produce a sound. A penholder with a sharp pen point touched to the record will produce a sound.

It may be possible to show the children the type of phonograph that produces sounds on the above principle. Older phonographs used this type of pick-up. Some children's phonographs still use this method. However, most modern phonographs use an electrical pick-up in which the vibrating needle produces a varying electric current.

Some toys operate on a principle similar to that used in phonograph records. One of these is a Christmas card that, when scratched rapidly by a finger nail says "Merry Christmas."

Operators of local radio stations will usually be happy to show the pupils how a record is cut. Sometimes they will make a record of the voices of the pupils and the class may then take the record back to school to play it. Tape and wire recorders are common today and it is usually possible to demonstrate one of them to the pupils. However, the principles of magnetic recording on tapes and wires are beyond the scope of this science programme.

### Pages 156–157–158

The principle involved in the voice box or larynx can be illustrated with the strips of thin rubber on a small funnel. It is also utilized in some toys such as the "squawker" on a balloon. The range of voices depends upon the length and thickness of the vocal cords. Vocal cords of men are longer and thicker than the vocal cords of women and boys. Vocal cords of boys grow suddenly at the time of puberty and bring about the "change of voice" that marks this period.

To help in an understanding of the ear a model is useful. Such a model can often be borrowed from the science department of a junior or senior high school.

### Summary Questions

1. A sound is the result of some object vibrating.
2. If a string is made longer or looser, its pitch is lowered; if it is made shorter or tighter, its pitch is raised. If a string is replaced by one of different thickness, its pitch is also changed.
3. The shortest bars of a xylophone have the highest pitch.
4. A person makes vocal sounds by blowing air past the vocal cords in the voice box.
5. Adding water to a bottle shortens the air column and raises the pitch of a sound made by blowing over the bottle.

6. Sounds usually come to our ears through the air. A few are transmitted through other substances on rare occasions.

7. The pitch of a flute is changed by opening or closing holes along its length.

**Follow-up**

Throughout the year new kinds of toy musical instruments are met, and each presents an opportunity to refer briefly to some of the principles of musical sounds. There are also occasional opportunities for the pupils to hear orchestras, bands, and individual musical instruments with which they have had no previous experiences. These situations may also be utilized. Some pupils may study instruments which they will enjoy explaining to the class.

Home-made musical instruments may be exhibited and demonstrated at parents' nights and science fairs. An interesting assembly programme can be built around the experiments and demonstrations of this unit, with a selection played on the home-made instruments as a finale.

## POSSIBLE LEARNINGS

Sounds are produced by things that are vibrating.

Pitch depends upon the speed of vibrations.

The pitch of a vibrating string depends upon its length, its tightness, and its thickness.

The pitch of bars of wood and metal depends in part upon the length of the bars.

The pitch of whistles and horns depends upon the length of the vibrating air column.

Sounds can be recorded by various machines.

Vocal sounds are produced by air blowing past cords that can be tightened or loosened at will.

Hearing results from vibrations being set up in our ears, the vibrations being caused usually by vibrating air.

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Brief explanation of sound principles. Illustrated.

*Sound; An Experiment* Book. Marion Baer. S. J. Reginald Saunders: Toronto, 1952. 127 pages.
An experiment book with drawings.

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*This Is an Orchestra.* Elsa Posell. Thomas Nelson: Toronto, 1950. 94 pages.
A picture guide to orchestral instruments and their function.

**Films**

*Nature of Sound.* Coronet.
The nature of sound simplified and clarified.

*Sound.* Gateway.
How vibrations are produced and sound waves carried.

*The Sounds of Music.* Coronet. Ontario Department of Education: MU-30
The proprietor of a music store demonstrates some properties of musical sounds and applies the principles to phonograph records and musical instruments in his store.

# Some Common Acids

## PURPOSE OF THE UNIT

Acids play an important part in the world. The life processes of plants and animals involve many acids. Erosion of rock materials is speeded by acids in rain water, in streams, and in ground water. Plants are materially affected by the presence or absence of acids in the soil. Industry has become increasingly dependent upon such acids in various manufacturing operations.

This study of acids is part of the major sequence in this Series dealing with chemical changes. Most of the preceding units in the sequence have dealt with oxidation. They include the second-grade unit "Rust," the third-grade unit "Fire and Air," and the fifth-grade unit "Controlling Fires." The fourth-grade unit "Things That Dissolve" has direct application to chemical processes.

This unit also applies to fields other than chemistry. It touches upon human physiology through its references to digestion. It touches upon fire prevention and the erosion of rocks. It helps to develop understandings of the interrelationships between plants and their environment.

This broad approach to the study of acids, with its direct application to commonplace phenomena, helps pupils to develop an interest in the things around them. Thus, a major goal of science education is met.

The experimental approach used in this unit permits pupils to manipulate materials and see at close hand reactions that are difficult to see at a distance. Many of the suggested activities encourage further experimentation. Pupils can speculate about related situations and devise methods for testing their guesses, thus practising what is sometimes called the "scientific method."

As part of the health and safety programme developed in this Series, pupils are warned about the harm that certain acids can do. Specific reference is made to the effect of lemon juice and certain soft drinks on teeth. However, pupils are not made to fear acids in general as might be the case were the dangerous acids given major attention.

## PREPARING FOR THE UNIT

The two chemicals needed in quantity for the activities suggested here are vinegar and baking soda. The vinegar may be the cheapest kind available. Additional purchases should include a small can of cream of tartar and another of baking powder. Buy the baking powder that is made with cream of tartar. Dilute hydrochloric acid needed for testing rocks can be prepared by a science teacher or a druggist. Small quantities of foods to be tested and the materials needed for such activities as baking biscuits are best brought from home by the teacher and the pupils as needed.

Most of the simple experiments can be carried out in drinking glasses or baby food jars. The unit will be most effective if there are enough of these materials to permit the pupils to work in small groups.

It is to be hoped that the school has facilities for doing some baking. If it has not, there are small ovens that may be used with electric hotplates. There are also electric ovens which might be borrowed.

The soda-acid type of fire extinguisher is common in many places. Arrange for a demonstration of the extinguisher by the fire department, a school janitor, or a science teacher. After the extinguisher has been discharged, show the parts to the children. If possible, let them see the process of recharging. The local fire department may be willing to help with this topic.

Try also to arrange for a trip to a chemistry or general science laboratory in the senior or junior high school. The science teacher may show some of the more dangerous acids and demonstrate what they can do.

In rural areas, the problem of acids in soils is a vital one. An agriculture teacher or an agricultural agent may be willing to tell the children something of the effects of acidity on plants, and they may be able to demonstrate soil-testing procedures. There are some very simple soil-testing kits that children can use. One of these might be borrowed.

**List of Materials**

- Vinegar
- Baking soda
- Baking powder
- Drinking glasses
- Spoons
- Matches
- Bottle with cork
- One-hole stopper to fit bottle
- Lemon
- Orange
- Grapefruit
- Tomato
- Paring knife
- Cream of tartar
- Wheat flour
- Glass tube
- Rubber tubing
- Dilute hydrochloric acid
- Hot-plate

## TEACHING THE UNIT

One strength of this unit lies in the opportunities for individualized pupil work. Encourage the pupils to carry out experiments at home, and provide them with materials for experimenting in school. Suggest variations of the experiments and let them devise problem solutions.

Many pupils are fascinated by chemical experiments, and they may wish to go beyond the scope of the present unit. Some of them have home chemistry sets and may wish to demonstrate certain experiments. Permit them to do as much as they wish within the limits of time and facilities, but such additional work should be considered as optional for interested individuals. There are aspects of chemistry that are too technical for most pupils at this level.

The word "acids" is the only special science word in this unit. It has been set in bold face.

### Pages 159–160–161

Many pupils have already mixed baking soda in vinegar by the time they have reached the sixth grade. Let some of these pupils demonstrate the experiment first. Then give the other pupils an opportunity to repeat it, preferably while working in groups of two. Use plenty of newspapers to soak up spilled liquids, and give the pupils wet cloths for cleaning up afterwards. It is sometimes wise to put plates or pans under the jars and drinking glasses to catch any of the liquid that bubbles over the rims.

The pupils have already been introduced to the gas called carbon dioxide in the unit "Plants That Are Not Green." The only new concepts developed here are that a match will not burn in the gas, and that the gas develops a pressure when produced in a closed space.

It is usually better to take the bottle outside when the cork is to be driven from it by the pressure of the carbon dioxide. However, it is possible to do this experiment indoors. Set the bottle in a pan to catch any liquid that bubbles from the mouth of the bottle.

There is a remote possibility that the bottle might break if it has a serious flaw in it and if the cork is driven in especially hard. Set the bottle in a deep tin can, and do not let the pupils crowd round the bottle during the demonstration.

**Page 162**

Bring a number of food items to school and ask the pupils to test them for acid. Then encourage them to experiment at home and report on their findings. It may be well to "forget" to bring one of the strongly acid foods listed on this page, perhaps the grapefruit, so that pupils may have an opportunity to discover acids at home.

**Page 163**

The important concept to be developed with this experiment is that water is necessary for acid-soda reactions. The pupils are also made acquainted with a dry acid used in many baking powders.

Encourage the pupils to try the experiment several times and not depend upon a single observation. Direct them to hold lighted matches in the gas given off.

**Pages 164–165**

There are two general types of baking powder. One type is made with cream of tartar and this type reacts as soon as water is mixed with it. Another type uses alum and this type reacts slowly in cold water but speeds up as the dough is heated in the oven. There are also double-acting types which give off carbon dioxide on mixing with water and later on being heated. The first type is best for our purpose.

After the pupils have produced a gas with baking powder, direct them to hold a lighted match in the gas. They may also blow a cork from a bottle by pouring water on a teaspoonful of baking powder in the bottle.

The pupils may make a baking powder by mixing cream of tartar and baking soda. Let them discover the proper proportions by experiment. Show them the following procedure. Dissolve a teaspoonful of cream of tartar in a glass of water. Then add baking soda a little at a time until there is no more reaction. The amount of soda used is the amount needed to mix with each teaspoonful of cream of tartar.

The effect of carbon dioxide on biscuit dough is easily seen through the glass sides of a jar or drinking glass. It is necessary to work rapidly lest the carbon dioxide escape during the mixing process.

Be sure to bake some biscuits with and without baking powder if at all possible. This makes the study much more meaningful.

**Pages 166–167**

Cooks bake several kinds of cakes and cookies without using baking powder but they often do not understand the action of the baking soda they use. A little study shows that many recipes require ingredients that contain acids. In gingerbread and molasses cake, it is an acid in the molasses that reacts with the baking soda to form carbon dioxide bubbles. In sour cream cake it is the acid in the sour cream. Sometimes vinegar or lemon juice serves the same purpose.

Encourage the pupils to study recipes and test the ingredients.

**Pages 168–169**

Permit the pupils to add a number of different acids to small quantities of milk, so they realize that the acids, rather than some other ingredient in the vinegar or lemon juice they try first, cause the curdling.

Provide them with materials to make cream of tomato soup, both with and without baking soda. The tomatoes should be fresh. Be sure they follow the recipe carefully and do not let them boil the milk because boiling also curdles the milk.

Today in this country cheese is infrequently made of sour milk. The milk is usually curdled with a chemical called rennet. This is a faster process and does not expose the milk to conditions that encourage bacterial growth for so long a time. However, sour milk cheese is still made in many parts of the world.

Many people eat sour milk curds. The milk is usually pasteurized and then a tiny quantity of a pure culture of sour milk bacteria is added. Thus danger from disease bacteria is lessened. The curds are on sale in many food stores as cottage cheese.

**Pages 170–171**

Pupils will often notice an increased flow of saliva just by thinking about pickles or lemonade. It is suggested that after the pupils have read this first paragraph a jar of sour pickles be opened and a bit of pickle be given to each pupil. (Technically, the saliva glands shown on page 170 are known as salivary glands.)

Encourage the pupils to look for recipes calling for vinegar. Many so-called "appetizers" contain vinegar or have a dressing that contains vinegar. Vinegar is also used by expert cooks in soups and stews.

Because pupils tend to carry ideas to extremes, it may be well to caution them against over-indulgence in such acid foods as pickles. Almost any practice is harmful if carried to extremes.

The acid produced by the stomach glands is, interestingly enough, hydrochloric acid, but it is dilute and does not injure the stomach lining as would concentrated hydrochloric acid. This acid has several functions, as described in the text. Digestion in the stomach cannot take place until the food has been made acid by the hydrochloric acid. But after the food has moved into the small intestine, this acid must be neutralized before the digestive juices added there can operate.

**Pages 172–173**

Any strong acid is harmful to the teeth, because it reacts with the lime in the teeth. Normally, the saliva reacts with any weak acids in the mouth and neutralizes them before they can harm the teeth. Acid drinks, however, bathe the teeth in acid and cause more or less etching, depending upon the strength of the acid and the time that the acid is in contact with the teeth. Sucking lemons puts comparatively strong acid on the teeth for a considerable period. Lemonade, on the other hand, is dilute and is quickly swallowed.

Certain "soft" drinks have been discovered to seriously affect the teeth of animals forced to drink the beverages. It is believed that they also affect human teeth. This is a serious matter because enamel cannot be replaced. The suspected beverages are made with phosphoric acid.

The really strong acids can be seen best in a chemistry laboratory. Try to arrange for a visit to one and ask the science teacher to demonstrate some of the things acids can do. He may show, for instance, how concentrated sulphuric acid "burns" wood and paper.

**Pages 174–175**

If possible arrange for a demonstration of a soda-acid fire extinguisher. A member of the local fire department may be willing to co-operate, or a janitor of the school may help if this type of extinguisher is used in the school. A small fire should be built outdoors and then the extinguisher may be used to put it out. Afterwards, show the pupils the interior of the extinguisher and let them watch the recharging process.

The model that is described on page 175 reverses the location of the soda and the acid. This is done to make the model a little more "foolproof." Because the soda is wrapped in the paper, the reaction does not start so suddenly and there is more time to direct the hose in the desired direction. However, one may approximate the real extinguisher more closely by hanging a vial of vinegar over a solution of baking soda in water. Care must be used not to spill out the vinegar before the desired time.

### Pages 176–177

Rocks that react with acid are most likely to be limestones. In a few regions one may find marble, which is limestone altered somewhat by heat and pressure. Marble may be distinguished from limestone by the greater degree of crystallization which sometimes makes marble look almost like sugar.

The chemical in limestone and marble that reacts with acid is calcium carbonate, sometimes known as "lime," although this last term is also applied to other chemicals. Calcium carbonate or "lime" is present in bones, teeth, and shells. Limestones are frequently little more than masses of shells cemented together by calcium carbonate.

A piece of limestone in acid disintegrates as the calcium carbonate reacts with the acid and goes into solution. The extent of disintegration depends upon the amount of acid and the length of time involved. A piece of concrete falls apart in acid because the acid reacts with the cement that holds the concrete together. If results of the experiment do not go far enough to satisfy the pupils, add new acid to the jar.

From the experiment, the pupils should be able to understand some of the processes of erosion that take place around us, particularly in regions where the native rock is limestone. They should also understand better some soil-making processes.

### Pages 178–179–180

Soils become acid because of a number of processes. Sometimes the original rock material is acid. Plants give off acids as they grow and as they decay. Heavy rainfall dissolves and carries away chemicals that neutralize acids.

Acid soils are commonly found in woodlands where there is a thick layer of humus. Most bogs were once shallow ponds that filled in with decaying plant material. Pupils are interested in the special plants of these regions and will profit by trips to study the plants. Especially interesting are the Pitcher Plants, Sundews, and the Venus Fly Trap, all of which catch insects. There are a number of good plant guides that will help in identification of these and other bog plants.

If a soil-testing kit is available, test some of the soils of the region. An agricultural teacher or county agent can be of help in locating a kit and showing how to use it. He can also give information about the use of lime to counteract acids.

### Summary Questions

1. The pupils should list those mentioned on page 162, together with others mentioned in the remainder of the unit and those discovered by experiment.
2. The gas given off is carbon dioxide.
3. Baking powder gives off bubbles of carbon dioxide and makes biscuit dough rise.
4. Weak acids cause limestone to bubble and eventually break up.
5. Milk sometimes tastes sour because of the acid given off by certain bacteria that live in the milk.
6. The soda-acid fire extinguisher is turned upside down so that the sulphuric acid can run out of its bottle and mix with the baking soda in the water.

### Follow-up

Follow-up in a unit of this type consists chiefly of giving the pupils opportunities to repeat experiments. The materials may be brought out after an interval, in which something else is studied, and put where the pupils have access to them. Many pupils like to repeat the experiments again and again.

In schools which have cooking classes for children, it may be possible to provide additional experience with acids used in cooking.

Opportunities for field trips and unusual experiences may arise long after the unit is over. As time permits, take advantage of these opportunities.

## POSSIBLE LEARNINGS

Acids are sour and react with baking soda.

Carbon dioxide is given off when acids react with baking soda.

The carbon dioxide from acid-baking-soda reactions is used to make cakes and other baked goods rise.

Acids curdle milk.

Some acids are dangerous.

Limestone reacts with acids in water and is eroded by the acids.
Soils are sometimes acid.
Some plants grow well in acid soils; others do not.

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Simple experiments in chemistry, with photographs.

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Simple experiments for home or classroom. Good directions.

*Science Magic.* Kenneth Swezey. McGraw-Hill: Toronto, 1952. 182 pages.

More simple experiments, with photographs.

# Electromagnets

## PURPOSE OF THE UNIT

This unit concludes the sequence on electricity and magnetism that runs through the Exploring Science Series. It builds upon and reviews the earlier units. The first-grade unit "Magnets," the second-grade unit "Fun with a Dry Cell," the third-grade unit "Magnetic Poles," the fourth-grade unit "Static Electricity," and the fifth-grade unit "Electric Circuits" contribute directly to this one. In its turn, this unit introduces concepts essential for an understanding of such devices as motors and telephones that will be studied in higher grades.

The activities suggested for this unit give pupils opportunities to work with tools and science materials. The experiments give them practice in following directions. The projects enable them to exercise initiative and ingenuity. These are outcomes that are as important as subject-matter outcomes. Many pupils find a deep satisfaction in working with their hands and meeting the problems that arise during the construction of things. Pupils who have difficulty with reading are in special need of such outlets.

Projects in electricity are always interesting to parents and to other adults who want to know what is going on in school; so much of the school programme does not mean much to outsiders. Projects such as electromagnetic cranes can be exhibited effectively. Good public relations exist when parents approve of and are proud of the things their children do.

## PREPARING FOR THE UNIT

Dry cells are essential for the unit. For best results there should be one dry cell for each pair of pupils. Fewer dry cells can be used by having the pupils work in larger groups, but individual participation is diminished accordingly. It is possible to teach the unit with as few as two dry cells, but individual manipulation is reduced to a minimum and some pupils may have no opportunity to participate.

Insulated wire is another essential. The wire recommended for this unit is Number 24, double-cotton-covered or nylon-covered, magnet wire. Wire of this type winds easily and its insulation stays on, thus making it possible to use the pieces of wire again and again.

Large nails are needed to serve as cores for the electromagnets. A few magnetic compasses are needed to test the poles of the electromagnets. Brads or other small nails are useful for the experiments in which the electromagnets pick up things made of steel.

For projects the pupils will need pieces of wood, including a few long, thin sticks for the masts and booms of the cranes. Such sticks may be cut in the school shop. The pupils will also need screws, screw eyes, stove bolts, washers, and nails. They will need a few tools, including metal snips, hammers, pliers, screwdrivers, and hand-saw.

The study of the telegraph and the electric bell are made much more meaningful with examples for study. When purchasing electric bells, be sure to specify that they are to operate on one or two dry cells. A telegraph set may be borrowed.

In many communities there are electromagnetic cranes which handle scrap steel in junk yards and which handle steel bars and plates in factories. Look for such a crane that the pupils can see in action and make arrangements for a trip. The pupils will gain a new outlook.

**List of Materials**

Dry cells
Insulated magnet wire
Large nails
Small brads or tacks
Compasses
Scraps of lumber
Tin cans
Screws, nails
Screw eyes, nail sets
Hammers
Tin snips
Pliers
Saw
Electric bells or buzzers
Screwdrivers
Stove bolts

# TEACHING THE UNIT

It may be desirable to review the third-grade unit on "Magnetic Poles" before introducing this one. Some pupils may not have studied this unit, and others may have forgotten some of the important points.

Provide as much individual participation as possible. If the supply of materials is inadequate, make the materials available on a special table so that pupils may experiment with them at their leisure.

After the pupils have constructed several projects, arrange for a demonstration to parents and other interested people. This may be done at P.T.A. meetings, parents' nights, and science shows. The pupils and their parents get much satisfaction from such events.

Remember that many of the important outcomes of this unit are a result of manipulation. There is less opportunity for extensive reading or picture study than in many other areas. In consequence, some pupils will gain more from the unit than other pupils. Do not try to hold all the pupils to the same standard.

**Pages 181–182–183**

The actual construction of an electromagnet should cause no problem. The only thing that can go wrong is to wind part of the coil in one direction and the remainder in the opposite direction. The two parts then oppose each other and the external force is reduced, sometimes to zero.

The switch shown (see "Electric Circuits," Book Five) is especially satisfactory for use with an electromagnet. The current through an electromagnet is large, and a dry cell's life is shortened rapidly if the dry cell is left attached to the electromagnet for any great length of time. With a switch of this type, the current flows only when needed.

It is suggested that brads be used in testing the strength of electromagnets. The brads are clean, easily picked up, and easily returned to the containers. Iron filings may be used but are less satisfactory.

It may be well to spend some time on the function of the insulation on the wire. Show the pupils that if there were no insulation, the electricity would pass from turn to turn and would go through the metal of the iron core without going through the full length of the coil.

Some pupils may be interested in the function of the iron core. Encourage them to try other materials such as wood, glass tubing, and rubber. They will discover that the magnetic force is reduced.

**Pages 184–185**

These experiments should present no particular difficulty to the pupils. They will discover that doubling the number of turns increases the magnetic force, and doubling the number of dry cells also increases the magnetic force. A count of the nails in each case may not show force to be exactly doubled, but it may approximate it. Encourage pupils to try the experiment a number of times and average their results.

### Pages 186–187

Before studying these pages, review the laws of magnetic attraction and repulsion. The convention in this Series is to call the end of the compass needle that points north the "N-pole." (The reasons for adopting this convention are given in the third-grade manual.) If the N-pole of a compass needle is attracted to an unknown pole, the latter must be an S-pole. Likewise, if the S-pole of the compass needle is attracted to an unknown pole, the latter must be an N-pole.

Stress the instruction on page 186 that says place the compass about an inch from the electromagnet. If the compass is placed much closer, its own magnetism may be affected, being reduced and even reversed. Caution the pupils to use distances greater than one inch.

The pupils will discover that each electromagnet has two poles, an S-pole and an N-pole, while a current is going through the coil. They will also discover that changing current direction reverses the poles.

### Pages 188–189–190–191

Several pupils may wish to make an electromagnetic crane. The first crane may be made by a small, interested group under some supervision. The construction may be done outside of the formal class period. However, once the pupils understand the techniques, they will work on their own. Surprising ingenuity is often displayed. Some pupils may mount their models on wheels. Others will make a crane that can be turned. A few add windlasses to wind up the string and have separate controls for the boom and the string holding the magnet.

There are on the market mechanical construction kits that include an electromagnet for making models of cranes. Some pupils may wish to use their own kits to make models that they bring to school for display. Other pupils gain more satisfaction from the cruder models they make from sticks and string.

### Pages 192–193

These pages mean much more to children if they have seen a similar crane in use. Try to show them one at a junk yard or factory.

Encourage pupils to describe the process by which steel scrap is loaded in the railroad car in the first picture. Then ask them to repeat the description as applied to the second picture.

Also ask the pupils to suggest ways that lumber, or things made of copper or aluminum may be moved by a crane. They can see readily the comparative simplicity of moving steel by an electromagnet.

### Pages 194–195

The telegraph set described here is simple to make and should present no difficulties to the pupils. If one dry cell is not strong enough to operate the sounder, connect two cells in series as shown on page 185. The sounder sometimes gives trouble because the steel strip seems to stick to the heads of the nails in the electromagnets. This is because the nails become magnetized like permanent magnets and hold the steel strip down. Press one or two layers of cellulose tape on the heads of the nails. This makes a small gap between the nails and the steel strip; the latter can thus pull away more easily.

Some of the pupils will enjoy sending messages on the telegraph set. Give them long lengths of wires so that the key may be placed on one side of the room and the sounder on another. It may be possible to put the key and sounder in separate rooms.

Show the children a real telegraph set if possible. It may be possible to borrow the equipment from a high school science department.

Should some of the pupils be interested in connecting two telegraph sets together so that messages can be both received and sent, refer them to general science books for proper procedures.

Teletypes can be seen in radio stations, newspaper offices, and telegraph offices. Arrange for the pupils to see a teletype on a field trip.

### Pages 196–197

Pupils may need a little help in locating the position for the long screw used in the model buzzer. The steel strip should not touch the screw when the strip is pushed down but it should hit the under side of the head when it springs up. Two dry cells may be necessary to operate the buzzer.

Give the pupils real buzzers and bells to operate. These should be designed for direct, not alternating, current.

Do not expect all the pupils to grasp the mechanics of electric bells and buzzers. The sequence of events in one of these devices is more complex than most of the devices they have been studying.

### Pages 198–199–200

Pupils greatly enjoy operating electric motors. Try to find some miniature motors that operate on electricity from dry cells. The science department of a junior or senior high school usually has one that may be borrowed. Sometimes pupils have toy motors of their own, but try to find out whether they can be used on direct current. Some are designed for 110-volt alternating current.

We are making no effort at this level to explain the operation of an electric motor. Neither are we suggesting the construction of electric motors for this level. Model motors are somewhat difficult to adjust. However, if certain pupils wish to make such models following plans they have discovered elsewhere, encourage them and help them to find materials to use. Sometimes it may be necessary to get a little help from a general science teacher or other specialist in making the final adjustments. Pupils who wish to know more about the operation of electric motors can be referred to general science books.

### Summary Questions

1. An electromagnet has two poles, an N-pole and an S-pole.
2. Increasing the number of turns or increasing the amount of electricity going through a coil increases the magnetic force.
3. Changing current direction in an electromagnet changes the nature of the poles, the N-pole becomes the S-pole, and vice-versa.
4. Electromagnets are used to pick up steel scrap in junk yards, and steel bars and sheets in factories. Electromagnets are used in telegraphs, bells, buzzers, and motors. There are other applications that the pupils may have discovered in their reading.
5. A good way for the pupils to answer this question is to consider the uses of electricity in their own homes. They may then broaden the discussion to a consideration of the use of electricity in places of business, in automobiles, in schools, in hospitals, and in factories.
6. Most of the electrical energy we use today comes from generators that are turned by water or steam turbines. The electrical energy in automobiles comes from generators turned by the automobile engine. A minor source of electrical energy is the chemical action in dry cells.

## Follow-up

Give the pupils opportunities to repeat the experiments at later times. It is sometimes advisable to put the materials away for a few weeks; then make them available again after studying some other topic.

Encourage the pupils to add to a collection of pictures about the uses of electricity on the bulletin board. Even after the display has been taken down, new pictures can be exhibited on the section devoted to current clippings.

Many trips taken for other purposes will provide opportunities for calling attention to things studied in this unit. A trip to a newspaper office to study the way a newspaper is set up will give the pupils a chance to see a teletype.

Plan an exhibit of models, bulletin board displays, and other projects for parents and other interested people. Use P.T.A. meetings, parents' nights, and school visiting days. Such exhibits are most effective if the pupils are present to demonstrate and explain their work.

## POSSIBLE LEARNINGS

When electricity flows through a coil of wire, the wire becomes a magnet.

An electromagnet has two poles, an N-pole and an S-pole.

The strength of an electromagnet varies with the number of turns of wire and the amount of current in the wire.

Changing the direction of the current reverses the poles of an electromagnet.

Electromagnets are used in many common electrical devices.

Electrical energy has become very important in the modern world.

## BIBLIOGRAPHY

### Books

*Boy and a Battery.* Raymond Yates. Musson: Toronto, 1942. 120 pages.
Simple experiments, simple materials. Many good diagrams.

*Boy's Book of Magnetism.* Raymond Yates. Musson: Toronto, 1941. 166 pages.
Clear directions requiring simple materials for experiments, tricks, and games with magnets.

*Experiments with Electricity.* Nelson Beeler and Franklyn Branley. Ambassador Books: Toronto, 1949. 145 pages.
Experiments with simple equipment. Some tricks for fun.

*First Electric Book for Boys.* Alfred Morgan. S. J. Reginald Saunders: Toronto, 1951. 263 pages.
An explanation of what electricity is, where it comes from, and what it does.

### Films

*Electromagnets.* Young America Films.
Builds slowly from a simple bar magnet to an electromagnet made from home materials.

*Magnetism.* Coronet.
Types of permanent magnets, attraction and repulsion, and everyday uses of magnets.

*Magnets.* Young America Films.
Demonstrates permanent magnets and electromagnets.

# Bird Study

## PURPOSE OF THE UNIT

The hobby of bird study is spreading to increasing numbers of participants. These range from invalids who must watch birds at feeding stations to robust personages who penetrate the wildest parts of the country. In almost every case the interests quickly spread over into related fields, as insects, mammals, plants, and rocks.

We should not expect to develop such hobby interests in every pupil but there are many boys and girls who need only slight encouragement to become enthusiasts. As their interest spreads to other things of the environment, one of the over-all objectives of a science programme is attained. As they develop new appreciations for the problems of living things and as they become conscious of the delicate interrelationships that exist in the world, other important objectives are attained.

This unit encourages independent work, both in and out of school. Pupils are expected to make observations, record them, find additional information by reading, and give reports to the rest of the class. Charts, paintings, and exhibits suggested as pupil activities are largely individual projects. Individual work of this type exercises initiative and ingenuity. The various types of reports and other projects permit pupils to express themselves according to their particular talents.

## PREPARING FOR THE UNIT

There are several advantages to initiating this unit during the winter months. In most sections of the country there are fewer confusing species of birds during that season. Many of the birds that are present stay through the year and will be seen again and again. Later, new species are introduced gradually as migrating birds appear.

To ensure the success of the unit, a teacher should become acquainted with some of the localities where birds are most likely to be seen during the different seasons. Local bird enthusiasts can usually give such information. If not, the teacher should investigate neighbouring thickets, waste areas, woodlands, and the borders of streams. Try to contact someone who maintains a feeding station for permission to watch the birds at the station.

Teachers in urban areas may find it necessary to emphasize such interesting species as pigeons, starlings, and English sparrows; and they will have the resources of nearby museums and zoos.

Among the things called for are raw materials for making bird houses. Heavy roofing paper is easy for pupils to work with, and it makes satisfactory bird houses. Scraps of wood, large tacks, split rivets, and some big-headed nails are also needed.

Pupils may wish to make other types of bird houses. They will need lumber, nails, and common carpentry tools.

A supply of feathers is required for part of the unit. These may be taken from a hen or other fowl being prepared for eating. The feathers may also be taken from a dead bird such as a crow or a gull. It is helpful to have a bird's wing that has been dried to an extended position.

Desirable materials not specifically called for are pictures of birds, mounted birds, unusual birds' nests such as the nest of a chimney swift, recordings of bird calls, and films showing the life histories of common birds.

There are often community resources little utilized by the average teacher. Many communities have bird clubs, whose members would be delighted to help. They will take interested children on trips, give illustrated talks to the pupils at school, and help in the formation of such clubs as Junior Audubon Clubs. They will also help the teacher in identifying birds, nests, and calls, and they will supply many interesting things such as unusual nests.

If there is a museum nearby, investigate it to see if it can be of help in the study of birds. Sometimes there are exhibits of mounted birds, and sometimes the museum has materials that can be loaned to schools.

### List of Materials

Heavy roofing paper
Scraps of lumber
Split copper rivets
Large tacks
Nails
Hammer
Coping saw
Feathers of several kinds
Poster card
Bird nests
Chicken bones

## TEACHING THE UNIT

Only a small portion of a bird study unit lends itself to formal classroom situations. Most of the work is best carried out informally and largely on an incidental basis. The best time to give a few minutes to bird study is when a new bird is seen from a classroom window or when a pupil comes to school anxious to tell about a robin's nest he watched being built. These situations lend themselves to some of the most effective teaching.

Many teachers make use of a nature report period, a few minutes set aside each morning for reports of things the pupils have seen. The reports are often summed up in a nature diary which is kept by a single pupil or by a committee. The diary is sometimes duplicated and a copy given to each pupil.

Field trips taken just to see birds are frequently a disappointment. Birds may be relatively inactive at varying times each day, and it is difficult to predict when these periods may come. And even when two or three people might see many interesting things, the presence of 25 or 30 noisy, active youngsters adds a factor that changes conditions.

It is usually better to plan trips for other purposes but to use a route that takes the group where the desired birds might be seen. Should the birds be seen, a few minutes may be devoted to watching them, and if desired, the original purpose of the trip may be postponed.

**Page 201**

The title page can be used to start a discussion about possibilities for bird study. The pupils may describe localities where birds can be seen at the present time and where birds might be seen at other seasons. They can discuss procedures for the class to use, and they can make plans for building bird houses, taking some bird trips, and collecting information from books and similar sources.

**Pages 202–203**

It is often possible to take the full class to see winter birds if there are places where birds can usually be found. A feeding station is one of the best of these places. Arrange for a visit as soon as school opens in the morning because there is more likelihood of finding birds at a feeding station then. There may be other possibilities that are unique to the region within walking distance of the school—garbage dumps, feed stores, grain elevators, and other places where birds might feed.

The pupils should be encouraged to make independent trips. Perhaps some optional trips can be planned for Saturday mornings. Permit the pupils who make observations to report to the class. Then encourage them to do some reading about birds they have seen.

If desired, a feeding station can be established. A simple one such as that illustrated on page 202, or one like the feeding station described in *Exploring Science Four* (Unit 6) can be used. Or the pupils may wish to build a more elaborate feeding station. If the station is set up, be sure that it is kept stocked until winter is over. Birds are unthinking creatures and return again and again to an empty feeder once they have developed the habit of visiting it.

**Pages 204–205**

The bird calendar is a well-known teaching device. It may be simple or elaborate. It may be decorated with pictures of colourful birds, or the birds shown may be only those reported. The biggest problem is the tendency of attention-loving pupils to report unusual birds they have not actually seen. Discreet questioning and reference to bird books for ranges and dates of migration are needed to keep the calendar from becoming ridiculous.

Migration charts are very useful in helping pupils realize the variation of migration habits. Plan to have them make charts of at least one winter resident, one permanent resident, and some summer residents that differ in the locality of their winter habitat. Most books telling about birds give such information. This work will be more meaningful if only birds that the pupils have seen in the field are used as subjects.

**Pages 206–207**

When collecting birds' nests be sure the pupils understand that birds do not use the nests a second time and that as long as the nests are collected in the winter no harm is done. Nests should not be collected after the mating season starts in the spring.

Some bird books give information about nests, and some have keys to help in identification. It is not always easy to identify all nests even from keys. Any bird specialist in the community can give much help.

Plan an exhibit of nests, with some showing pictures of the makers, and with others taken apart to show the materials of which they are made. The exhibit can be used at meetings of parents. It can be displayed in a case in the hall of the school, or in the window of a store, or at a science fair. Pupils need adult recognition of their work.

**Pages 208–209**

Use pictures to introduce this topic and ask the pupils to investigate additional pictures. They may make pictures of males and females of species that they expect to see. As new birds are seen in the field, one thing for the pupils to discover is whether there is a difference in appearance of the two sexes.

### Pages 210–211

Pupils need a little supervision and some occasional hints while making this type of house, but it is one that all pupils can make.

The greatest problem is the making of the base for the house. This must be sawed out with a coping saw after the circle has been laid out with a compass. Sawing the disk is a slow process and if there is only one saw this step will hold up the others. It may be possible to have the disks sawed out in the school shop or in a local woodworking shop, although it is better for the pupils to feel that they themselves have constructed the houses entirely.

Roofing paper should be cut with a pair of metal snips or a pair of old shears. If the paper is warm, it handles more easily.

The pupils may need help putting on a perch until they see how it is done. Use soft wood for the perch because soft wood splits less easily. The perch should be laid on the workbench, the rectangle of roofing paper that will be the side of the house should then be laid on it, and adjusted so that the perch is about an inch below the doorway. The small circle of roofing left from the doorway is then placed as shown in the diagram, and large tacks are driven through it and the side of the house into the perch. When the house is assembled, this circle of roofing will be inside; the perch will be outside.

Riveting is done by punching holes in the roofing where the rivets are to go and then pushing the rivets through these holes. The split part of the rivets are spread apart and hammered flat.

When rolling the side of the house into a cylinder, it is well to roll it to fit the disk of wood that will be the bottom of the house. Then there will not be gaps at the bottom.

The pole to mount the house on should be eight or ten feet long.

Some pupils may wish to make wooden bird houses instead of this one. Encourage them to do so. Suggest that they follow plans found in books about birds rather than plans devised by themselves. Too many houses designed by people who do not understand birds are houses that the birds cannot—or will not—use.

### Pages 212–213

The territory habit of birds is especially interesting. It gives many people something new to look for in birds. Many pupils will not have the patience to carry out a careful study of a territory, but they can look for approximate boundaries. Song sparrows are among the birds more easily studied in this respect. The male is a strong singer and he chooses a shrub or low tree in a conspicuous place for a singing perch. His territory is also often located in yards and flower gardens.

If the teacher locates a male song sparrow that has set up a territory near school, she should plan a short field trip to see and hear him. In early spring on warm, sunny days, the song sparrow performs most of the time, and the class can become well acquainted with his appearance and his song.

### Pages 214–215

Feathers are the distinguishing characteristics of birds. No other animals have them. These feathers are extremely efficient, and except for a few cases of ornamental feathers, they are completely functional. Feathers are excellent heat insulators, especially the fluffy kind which trap air between their fibres. They are also nearly waterproof, due to their tight structure and to an oily secretion that the bird spreads over them.

Flight feathers are interestingly built. The quills are light but very strong. Each feather is curved so that it traps air on the down stroke of the wing and lets the air slip past easily on the upward stroke. It is difficult to imagine a structure more efficiently designed for this task.

A view through a microscope will show the pupils the means by which the tiny, hair-like parts of a flight feather are hooked together. Fluff does not have these hooks.

Charts of the locations of the different types of feathers on a bird help pupils to understand the degree of specialization that feathers show. These charts represent a good way to make use of the dead birds that pupils so often bring in.

### Pages 216–217

If you can get the wing of a bird, demonstrate how effective the wing is. Wave the wing downward and note the strong upward force. On the return stroke note how easily the air slips between the feathers.

The arrangement of the feathers is interesting. The longest feathers are on the outer ends where the mechanical advantage is most favourable for flight. The bases of the feathers where air might slip through are covered with a shorter set of feathers. In many cases the bases of this second row of feathers are covered by a still shorter set.

Sometimes one may see birds such as gulls and vultures that flap their wings slowly. Encourage the pupils to note the motion of the wings and compare it with the pictures at the top of these pages. Encourage pupils to watch birds landing and taking off. The ways some of them check their speed before landing is interesting to airplane-minded youngsters. Suggest that they watch pigeons and gulls.

### Pages 218–219

Most pupils have noticed the breast meat of chickens, but they rarely realize that this meat is made up of flight muscles. Although chickens today rarely fly and the muscles are practically useless, they must have been good fliers when they were wild birds. Bring in an uncooked chicken breast, so the pupils can notice the arrangement of the muscles. Then cook the breast and separate the meat from the breast bone.

The skeleton of a bird such as a chicken is interesting. If possible, show the pupils a mounted bird skeleton in a museum or a high school biology department. Most of the bones have counterparts in the human skeleton although some of the bones are greatly modified. The pupils will be interested in discovering that the wings of a bird are comparable to our arms in position, bones, and muscles.

Bones remaining from a chicken or turkey dinner may be cleaned by boiling in soap and water. They may then be compared with the picture of the bird skeleton in order to identify them by location. The breast bone is interesting. It has a large keel to which the strong breast muscles are attached. The human breast bone has no keel.

The hollow bones are also interesting. They combine both strength and lightness, important characteristics for flying animals.

### Pages 220–221

Open an egg for the class and show them the white spot which develops into a young bird if it is fertilized and incubated. In a later unit "Fish Life" the concept of the sperm is introduced. If the problem of mating arises during the present unit, and it frequently does, the concept may be introduced at this time. Otherwise, refer to the white spot on a bird's egg when sperms are discussed in the unit on fish.

The arrangement of yolk, white, and air space can be demonstrated by boiling an egg and slicing it open from end to end. This was suggested in *Exploring Science Two*; it may be repeated here.

Birds that brood their eggs have patches of bare skin on their breasts. Thus the eggs are kept against the skin rather than being separated from it by an insulating layer of feathers. The time of incubation varies: it is about two weeks for song birds and about three weeks for fowls. Pupils may be interested in investigating incubation habits of various birds and reporting to the class about their findings.

### Pages 222–223–224

The two general patterns of young bird development are described here. Rural children have usually seen examples of both, although their acquaintance with the second group may be limited to chickens raised in an incubator. Sometimes it is possible to observe a robin's nest from a window in the school and the pupils may watch the development of the young. Individual pupils may be able to watch a nest at home and report on the development. Encourage these pupils to keep a diary.

When studying the cowbird, try to discourage any antagonism that the pupils might feel because of the parasitic habits of this bird. Unfortunately, some children's literature makes the cowbird seem especially evil. Unquestionably, cowbirds do interfere with the successful nesting of the host birds, but none of the species parasitized seems any the worse because of it. There is a natural balance in numbers of each species; if the number is exceeded, the excess population will be killed off by some other factor.

#### Summary Questions

1. The answer to this question will vary with each locality.
2. The answer to this question will vary with each locality.
3. Most of the so-called song birds, the hawks, and the owls have young that are helpless when they hatch. However, the young of wild ducks, pheasants, and grouse are able to walk around as soon as they hatch.
4. The flight muscles in the breast are the largest muscles in most birds. The exceptions are the flightless birds such as the ostrich.
5. Feathers serve as heat insulators and shed rain. The wing feathers make a light, strong surface that presses on the air during flight.
6. Goldfinches and redwings are mentioned in the text. The pupils should add others with which they become acquainted.

### Follow-up

Ideally, a unit on birds does not end until the school year is over. The migration season introduces many new birds to be investigated. The nesting season provides opportunities for observing individual birds setting up territories, building nests, incubating eggs, and taking care of the young.

Opportunities may arise to take advantage of special features such as speakers from a bird club, new films, and the like. The formation of a Junior Audubon Club may also be considered as part of a follow-up.

## POSSIBLE LEARNINGS

Some birds live in a region all year long.

Some birds migrate to northern regions in summer and to southern regions in winter.

People can attract birds to their yards with feeding stations and bird houses.

Most birds are well adapted for flight.

Most birds give their young much care.

## BIBLIOGRAPHY

### Books

*Book of Birds for Young People.* Ferdinand Mathews. McClelland and Stewart: Toronto, 1921. 323 pages.

Deals with migration and contains some material on songs.

*Field Guide to the Birds.* Roger Tory Peterson. Thomas Nelson: Toronto, 1947. 290 pages.

A guide book that every teacher and many children will learn to use and like.

*First Book of Birds.* Margaret Williamson. Ambassador Books: Toronto, 1951. 69 pages.

Here is help on bird anatomy and mating exhibitions.

*Traveling with the Birds.* Rudyard Boulton. Book Society: Toronto, 1933. 64 pages.

Has good information on migration.

### Films

*Birds Are Interesting.* Encyclopaedia Britannica Films. Ontario Department of Education: SN-100.

Contrasts such features as bill, feet, and wings, and classifies birds under the three categories of swimming and wading birds, perching birds, and birds of prey.

*Birds of the Dooryard.* Coronet. Ontario Department of Education: SN-126.

Seven common species found throughout our nation.

*Birds of Prey.* Encyclopaedia Britannica Films. Ontario Department of Education: SN-14.

Seven common species shown in their natural habitats.

*How Birds are Fitted for Their Work.* Society for Visual Education.

*Common Birds of Canada.* National Film Board.

*The Red-Winged Blackbird.* Coronet.
The life history of this common and interesting bird.

**Recordings**

*Canadian Bird Songs Album.* Cornell University. Thomas Allen: Toronto.

*American Bird Songs—Vol. 2.* Thomas Allen: Toronto.

*Sounds of Nature—Vol. 1, Vol. 2, Vol. 3.* Federation of Ontario Naturalists.

*Songbirds of America.* Soundbook. Thomas Allen, Toronto.

# How Airplanes Fly

## PURPOSE OF THE UNIT

Airplanes have become a common and important part of our environment. Everyone should know something of flying principles.

This unit is part of a sequence dealing with machines. It builds specifically on the second-grade unit "Wind" and the fourth-grade unit "Airplanes," but it uses concepts developed in many other units.

The approach used in this unit provides for several different talents and interests. Pupils with mechanical aptitudes like to make models of planes. Pupils who like experiments enjoy testing those suggested here. Avid readers find numerous possibilities for book research. And pupils with interests in drawing find many opportunities to draw.

There are also many possibilities for correlation with other subjects. Study of airline routes and timetables, the calculation of distances, and the comparison of different kinds of maps involve both geography and mathematics. The impact of the airplane on society as a means of rapid travel, of opening new areas to commerce, of stimulating new industries, of carrying war to areas removed from boundaries—all these are in the field of social studies.

## PREPARING FOR THE UNIT

The only item on the list of materials that is not readily available is the balsa wood needed for model planes. This wood may be purchased in stores that sell model-making supplies. The number of sticks to be purchased depends upon the number of models to be made. Ideally, each pupil should make a model, but a single model will serve to demonstrate some of the principles of flight to the whole class.

Arrange for a trip to an airport if possible. The trip may include more than a study of airplanes. It may include a study of the weather station and it may go into airport management in some detail.

List of Materials

Thin cardboard
Bottle
Cork
Quick-drying glue or cement
Pins
Thread
Paper
Cards
Thumb-tacks
Rulers
Electric fan
Rubber balloons
Small beads
Rubber bands
Tracing paper
Paper clips
Balsa wood sticks

## TEACHING THE UNIT

Pupils vary a good deal in the background they bring to the study of airplanes. Some pupils have little knowledge and few experiences. Some will have visited airports, travelled by plane, made models, and read extensively. Take advantage of the experiences of these latter children by letting them take leadership in activities suggested here. They may add many other ideas that are worth following up.

Be sure that all the pupils participate in the basic experiences. Then permit them to diverge into separate areas according to their interests.

**Page 225**

The title page can be used to review the knowledge of the parts of an airplane. Some of the parts and their uses are listed below:

a) Wings
    Wings serve to support the plane in the air.
b) Motors
    The motors turn the propellers.
c) Propellers
    The propellers move the airplane ahead.

d) Landing wheels

The two large wheels near the front of the plane and the smaller wheel at the tail are used by the plane as it moves on the ground. Some planes have a nose wheel instead of a tail wheel.

e) Rudder

The rudder is the movable flap on the rear of the vertical section of the tail. It steers the plane.

f) Elevators

The elevators are the movable flaps on the rear of the horizontal section of the tail. They control the diving and climbing of a plane.

g) Ailerons

The ailerons are the movable flaps on the rear edges of wings near the outer ends. The ailerons tip the plane or bring it to a level flying position.

h) Landing flaps

Landing flaps are movable sections of the rear edges of the wings nearer the body of the plane than the ailerons. These flaps serve both to slow down the plane in the air and to increase the lifting effect of the wings at slow speeds.

Some pupils will know about other devices on airplanes and they will want to tell about these devices. Permit them to do so, and encourage them to illustrate their points with diagrams, pictures they have cut from magazines, and with models.

**Pages 226–227**

If possible, show the pupils the cabin of a plane during a trip to an airport and ask to have the controls demonstrated. If a trip cannot be taken, use photographs of the cabin interiors. Some pupils will be interested in the many instruments, switches, and levers in some of the cabins. Refer them to books on aviation in the library.

The manoeuvres pictured on page 227 are produced by the following procedures:

Left turn—Made by pressing the left rudder pedal, which turns the rudder to the left. In addition the plane is usually tipped (banked) to the left by turning the wheel to the left (or by pushing the stick to the left in some planes). Tipping the plane keeps it from slipping sidewards.

Right turn—Made by pressing the right rudder pedal. The plane is tipped (banked) to the right by turning the wheel to the right.

Dive—Made by pushing the wheel (or stick) forward. This turns the elevators down.

Climb—Made by pulling the wheel (or stick) back. This turns the elevators up.

Banking—Made by turning the wheel to the left for banking the plane to the left, or by turning the wheel to the right for banking the plane to the right. (Or by moving the control stick to the left or right respectively.)

Landing—The pilot approaches the field in a shallow dive with the wheel pushed forward to push the elevators down. Near the field he levels off the plane by pulling the wheel to a neutral position. Just as he is about to land, he pulls the wheel back a bit to raise the elevators. This helps to keep the plane from turning over when the wheels touch.

### Pages 228–229–230–231–232–233

These control surfaces of a plane have been touched upon in the fourth-grade unit "Airplanes." This unit suggested making paper gliders that have these control surfaces. It may be desirable to repeat some of these experiences.

Pupils may wish to make more elaborate models for the experiments shown here. These models may range from cardboard models like the ones described here (but including all control surfaces on one model) to wooden models. Some pupils may also buy models with movable control surfaces and demonstrate them to the others in the class.

A trip to see the control surfaces of a plane is desirable at this time if several trips can be taken. Otherwise, it is better to defer the trip until other features of airplanes have been considered. If the trip is taken at this time, locate the rudders, elevators, and ailerons on one plane and ask to have the movements of these surfaces demonstrated. Then find the same parts on other types of planes.

Study the pictures of different kinds of planes to find the control surfaces. Make labelled diagrams of some of these planes.

### Pages 234-235

Most people think of the upward force on an airplane wing as being due to the piling up of air under the wing as the wing moves forward in a slightly inclined position. It is true that a part of the upward force is due to this air. However, experiments have shown that about two-thirds of the total upward force on a wing is due to a reduced pressure above the wing as shown in the diagram at the bottom of page 234. Some pupils may be able to understand a discussion of the higher pressure beneath the wing and the reduced pressure above the wing, but it is felt that for the class as a whole it is adequate for us to show them that both the air going over the wing and the air going under the wing contribute to the upward force.

Besides the two demonstrations suggested here, there are other demonstrations of a similar nature in elementary books on airplanes. Encourage the pupils to read about these demonstrations and to perform some of them.

Spend some time studying the shape of the wings of a plane either in a picture or on a trip to an airport.

### Pages 236–237

On page 236 the propeller is treated as a fan. Few pupils know that an electric fan is subjected to a backward push even as it pushes the air forward, so this demonstration is an enlightening one. The principle is directly applicable to an airplane.

Electric fan blades are usually flat but propellers are much more carefully designed to give all possible force. Call the attention of the pupils to the shape of a real propeller or to one carved from wood for a model plane. Have them notice that at any point along this blade, the propeller is shaped like the wing of a plane. Some of the pupils will be able to see that the force exerted on the propeller is the same type of force exerted on the wing of the plane.

This demonstration of a jet using a balloon is one of the simplest possible. The pupils can also see jet action applied in rotary lawn sprinklers. At some airports the pupils may see a jet plane. They may collect pictures of jet planes and locate the jet openings.

### Pages 238–239

It is not the intention of these books to go into the technicalities of gasoline and jet engines. Few pupils are ready for this study. Those that are ready can be encouraged to do independent investigation in encyclopedias, general science books, and elementary books.

The point to be brought out on these pages is that there are two general types of airplane engines with certain general characteristics. The pupils should be able to identify them.

### Pages 240–241–242–243

The model propeller shown is easily made but is not very efficient. Some pupils may wish to carve and try out propellers made of balsa wood. Model-making kits will give them directions. Finished propellers can be tested by attaching them to the soap box as shown on page 241.

The simple model plane should present no difficulties. The balsa stick must be purchased from a store handling model-making supplies. The tail may be assembled with quick-setting airplane cement or with regular glue.

The adjustment of the wings is critical. The wings should slant upward as shown so that the plane does not slip sideways like a falling sheet of paper. If the plane noses downward during flight, shift the wings forward a bit. If the plane noses upward too much, shift the wings back.

Some of the pupils may have built flying models and they will enjoy demonstrating them. Usually, one must turn to the older boys for such demonstrations. By inquiring, one can quickly learn whether there is a boy who has made a hobby of model planes. Such a boy can put on some interesting demonstrations of rubber-band-powered models and perhaps of gasoline-powered models.

### Pages 244–245

Air resistance is an important factor in designing any devices that move through air at high speeds. Pupils may be conscious of the forces developed when they ride their bicycles and when they hold a hand out of the window of a rapidly-moving automobile. They may wish to consider streamlining of autos and trains as well as of airplanes.

The ideal streamlined shape is the "teardrop" shape pictured at the top of page 245. Many natural applications of this shape can be seen in birds and fish. Ships, submarines, aerial bombs, automobiles, and —of course—airplanes approximate this shape as nearly as possible. In planes, the entire body of the plane is close to the teardrop shape. Each engine is enclosed in a teardrop-shaped covering. The tail surfaces approximate it in cross-section. Even the wing struts of small planes are streamlined.

### Pages 246–247

The four general forces acting on an airplane are defined and illustrated here. When the plane is in level, uniform flight, the forces are in balance. When a force becomes larger than the opposing force, the plane speeds up, slows down, rises, or settles, depending upon which forces are unbalanced. Usually, these forces interact on each other so that the total picture is complex. At this grade level, however, it seems wiser to consider the forces independently and avoid complications.

### Pages 248–249–250

A study of airplane types should include the collection and display of pictures. Some pupils may also like to make drawings of different types. There are kits for making non-flying scale models of different kinds of airplanes. Many pupils have some of these models already and they will make more with a little encouragement. A display of these models should be a feature of the science programme.

Visits to an airport may show several airplane types, especially among the smaller, privately-owned planes.

Page 248 shows (left-to-right and top-to-bottom) a biplane, a high-wing monoplane, a mid-wing monoplane, and a low-wing monoplane. Page 249 shows a float plane and an amphibian at the top, and a seaplane at the bottom.

#### Summary Questions

1. The upward force on an airplane wing is due to air flowing under and over the wing. Pupils who have read more deeply may explain that there is a higher pressure under the wing and a lower pressure over the wing, with the upward force being due to pressure difference.
2. The propeller pushes back on the air and this makes a forward push on the propeller. The forward push moves the plane ahead.
3. The four important forces acting on a flying airplane are the pull of the earth, the force of the air on the wings, the force of the air on the propeller, and wind resistance.
4. As hot gases rush from the back of a jet engine, they make a force on the engine that drives the engine ahead.
5. The pilot banks his plane by turning the control wheel (or stick). This turns one aileron up and the other down.
6. The elevators of an airplane make the plane dive or climb. When the elevators are turned down, the plane dives; when they are turned up, the plane climbs.
7. The air resistance of a plane is kept small by streamlining, that is by making all parts as near the "teardrop" shape as possible. Let the pupils make drawings to illustrate their answer to this question.

### Follow-up

If a new type of airplane comes to the local airport, encourage the pupils to see it. Arrange for a class trip if possible.

As pupils make flying models and scale models put them on display. Also encourage the pupils to be on the alert for good pictures of airplane types for the bulletin board or the class scrapbook. At a parents' night or a science show, exhibit the pictures and models.

## POSSIBLE LEARNINGS

The upward force on airplane wings is due to air moving over and under the wings.

Airplanes are controlled by the rudders, elevators, and ailerons.

Some airplanes are moved by propellers that are turned by gasoline engines; some are moved by jets from jet engines.

Wind resistance is reduced by streamlining.

There are many types of airplanes developed for different uses.

## BIBLIOGRAPHY

### Book

*Model Planes for Beginners.* Horace Gilmore. Musson: Toronto, 1947. 95 pages.

Chapters on building planes, identification of planes, and the good workshop.

### Films

*Air in Action.* Coronet.

The nature of air in motion as applied to many common things including airplanes.

*Air Transportation.* Encyclopaedia Britannica Films.

*SS-1 An Aeroplane Trip.* Ontario Department of Education.

This film shows the experiences of Dorothy and her mother during an aeroplane trip from Los Angeles to Salt Lake City.

# Warm Air in Motion

## PURPOSE OF THE UNIT

Movements of heated air are so numerous and so commonplace that we are apt to take them for granted. A brief listing of some of the more important examples makes a convincing argument for inclusion of this study in a science programme. We find that rooms and sometimes entire homes are heated by the movement of warm air. Fires burn more or less briskly, depending upon the movement of air heated by the fire. Nearly all major and minor weather phenomena are due to the unequal heating of the atmosphere.

Previous units have touched upon this subject. Experiences with effects of heating air were introduced in the third-grade unit "Fire and Air" and in the fifth-grade unit "Warm Weather Indoors." Many other units contribute to the present unit, including the third-grade unit "Sunshine" and the fifth-grade unit "Rainbow Colours."

This unit fits into several sequences, particularly the sequences on heat, gases, and weather.

The unit provides many opportunities for pupils to carry out experiments and devise variations of the suggested experiments. They are encouraged to observe commonplace phenomena such as cumulus clouds and air currents around a fireplace. The unit attempts to enrich the lives of pupils by increasing their interest in surroundings.

## PREPARING FOR THE UNIT

Few materials are needed for this unit beyond the things usually available in the classroom or from nearby sources. The only items that may not be immediately available are an electric hot-plate, an electric lamp with socket and lead cord, and some candles.

Pictures of such things as cumulus clouds, thunderheads, and tornadoes help to enrich the study of local winds. Diagrams and charts of thunderstorms, hail formation, and tornadoes are useful.

The work of the unit is best suited for early fall or late spring in northern regions. Over most of the United States, it is well suited for either the full autumn and spring seasons when there are cumulus clouds, thunderstorms, and similar phenomena.

**List of materials**

Electric hot-plate
Electric lamp and cord
Thin cardboard
Candles
Thread
Bottle
Modelling clay
Soda straw
Sticks
Paper bags
Black and white drawing-paper
Pans
Soil
Thermometers
Scissors

## TEACHING THE UNIT

In this unit, experiences with indoor air in motion are used to precede the study of local winds. Experience has shown that an understanding of the motions of air is easier with this approach, and it is recommended for most teaching situations. However, this does not mean that advantage cannot be taken of some experience such as a thunderstorm before the first part of the unit has been dealt with. It means, instead, that the thunderstorm is observed and discussed in descriptive terms and the study of principles is deferred until later.

Encourage the pupils to apply their discoveries to the many common situations that involve the heating of air. They will discover many more than are mentioned here.

### Pages 251–252–253

These pages suggest experiences that show that warm air rises. The first one, involving a hot-plate and dandelion down, needs little additional discussion except to mention that the hot-plate should be turned on several minutes in order to become truly hot, and the down should be light. Other kinds of down, as from milkweed, work equally well.

Pupils may have some trouble cutting out a good spiral. Specific dimensions cannot be given here because the weight of the paper used varies so much. However, if the spiral is too weak, the original lines are too close together. If the spiral is too stiff, the lines are too far apart. A few trials should give good results.

### Pages 254–255

Some of the pupils may wish to find out more about some of the ingenious devices that tepee-living Indians invented to control the circulation of air in their dwellings. They used smoke-flaps round the opening at the top and shifted these flaps as the wind changed. They put a lining inside the tepee at the bottom so that incoming cold air was forced to come in above the heads of people sitting on the ground without blowing directly on their backs.

The simple demonstration suggested here with a model tepee also shows principles of the action in chimneys, stoves, and fireplaces.

### Pages 256–257

These two experiments show that air expands and becomes lighter when heated. Both are carried out with commonplace materials. The expansion of a gas can be demonstrated by the use of a thin-walled chemistry flask with a glass tube and a one-hole rubber stopper. The flask, being thin, transmits the heat of the hands to the air inside more quickly than the bottle. The flask may also be heated with the flame of a match or by holding it over a hot-plate.

If the bottle or flask is cooled while the straw is under water, water flows into the straw because air grows smaller as it cools.

Be sure to hold the paper bag in the second experiment because the force of air rising from the bulb or candle will move the bag upward otherwise. When the air in the bag is heated, take away the source of heat first, and then let go of the bag.

### Pages 258–259

Warm air rises, not because it has some magical anti-gravity property, but because it is pushed up by heavier cold air, much as oil is pushed up by heavier water. The explanation given here involves three steps: 1) air expands as it is heated, 2) the air becomes lighter as it becomes bigger (that is, the same volume of air becomes lighter), 3) the heavier cold air above it flows down and pushes the warm air up.

This reasoning is not simple and many pupils may not follow it through completely. This is not a matter for serious concern. Help as many pupils as possible to grasp the explanation, but do not insist upon mastery for the others. The science programme in later grades is designed to deal with more abstract concepts such as this one.

### Pages 260–261

The work of these two pages is a review of similar material in the fifth-grade unit "Warm Weather Indoors." If the pupils seem uncertain of the material, give some time to discussion, and take the pupils to study the circulation in stoves and fireplaces. Such circulation can be demonstrated by holding smouldering tissue paper near the draughts of a furnace and the opening of a fireplace.

The diagram on page 261 shows ducts built into the sides of the fireplace. Air is heated and recirculated in these ducts.

Encourage the pupils to make studies of the furnaces and fireplaces in their own homes and to make diagrams that show the circulation.

### Pages 262–263

Because sunshine is the chief source of heat energy in the world, the conditions that influence absorption of solar energy are important. Reflection is one of the most important factors. This was touched upon in the fifth-grade unit "Rainbow Colours," and demonstrated by putting a shiny can of water beside a dull black can of water in bright sunlight. That experiment can be repeated here if wished.

Another factor that influences the temperature of an object in sunlight is the material of which the object is made. Water requires more heat energy to make it change in temperature than almost any other substance. In addition, heat energy is often used to evaporate water rather than to raise its temperature. It can be seen that final temperatures are apt to be the result of several factors rather than one. At this level, however, the important thing for pupils to learn is that different surfaces are apt to have different temperatures when exposed to sunlight.

**Pages 264–265**

The first of these pages applies the findings of the last two experiments. Shiny metal is usually cooler than black metal beside it, particularly if the black metal is dull in finish. A black-top drive is usually hotter than a concrete walk for the same reason. Grass is much cooler than concrete because the leaves contain water and because some of the water evaporates. Bare soil is hotter than grass-covered soil because of differences in reflection and the amount of water present. Pupils will discover many interesting differences in temperature. The causes for variation are mentioned in the preceding paragraph.

Air is not heated appreciably by sunlight, the infra-red rays passing through it without being absorbed to any extent except by dust and water vapour. Air is heated chiefly by contact with hot objects. Pupils can see one effect of this on bright, sunny days. The air over roads and sidewalks shimmers as currents of heated air rise. Frequently the same effect can be seen over bare, dry fields but less often over grass-covered fields.

**Pages 266–267–268–269**

These pages apply to local winds the principles discovered by experiments and first-hand observations. Rising and falling air currents are little suspected by people on the ground who feel only light breezes flowing toward the heated areas. But people in airplanes are conscious of the effect of the rising and falling currents as they are bumped and tossed about on sunny days. On cloudy days and at night there is no local heating to cause rising air currents. Some pupils may have taken plane trips and noticed the effects without understanding the causes. They will be particularly interested in this phase of the topic.

Land and sea breezes are regular features at beaches in summer. They may come within the experiences of some of the pupils. In inland areas, there is little point in stressing this section of the topic.

**Pages 270–271**

Cumulus clouds are common on bright sunny days when there is enough moisture in the air. In observing them, ask the pupils to imagine the rising currents of air that form the clouds. Because the tops of the clouds usually billow upwards to some extent, it is not difficult to imagine rising air currents carrying up the tiny drops of water that make up the clouds. The bottoms of cumulus clouds, on the other hand, are nearly flat and are at approximately the same level. This is because the air above this level is cool enough to condense the moisture in the air, and the air below is too warm.

The sequence of cumulus clouds through a sunny day commonly follows the pattern shown. As the soil is heated to a maximum temperature in midafternoon, the air currents rise faster and in greater numbers. But as soon as the soil begins to cool, the currents decrease in number and finally cease near sundown. Moisture affects cloud development. On moist days, cumulus clouds may develop early in the morning, and on dry days they may not develop at all.

### Pages 272–273–274–275

Local thunderstorms are usually caused by the same conditions that have been described under cumulus clouds. The thunderhead is a type of cumulus cloud, but its appearance indicates that the ascending air moves very rapidly and contains much moisture. These two features bring about directly or indirectly the other features of a typical thunderstorm. The appearance of the cloud is described in the text. The savage blasts of wind before the storm are a part of the circulation of the air that makes the cloud. Hail is formed by ascending and descending currents that are strong enough to lift balls of ice as much as two inches in diameter. Lightning is a result of the tearing apart of raindrops (according to theory), and thunder is produced.

Review with the pupils the safety precautions they should take during thunderstorms. These were considered in the fourth-grade unit "Static Electricity."

### Page 276

Tornadoes are spectacular because of the damage they do. In regions where there are tornadoes, spend more time on the conditions that bring them about and what to do about them. In other regions, give them passing attention.

#### Summary Questions

1. Air expands and becomes lighter when it is heated.

2. Heated air tends to rise because it is lighter than cool air at a higher level. The cooler air moves down and pushes the warm air up.

3. You can find heated air moving around radiators, stoves, and furnaces. On a small scale you can find it rising from electric lamps and cigarettes.

4. A pilot expects to find rapidly-rising air currents over bare fields, under cumulus clouds, and within thunderstorms.

5. Cumulus clouds are formed when rising air reaches a level where the air has cooled enough to condense water vapour in the air.

6. A thunderhead is a cumulus cloud that is so tall that the top part of it is above the freezing level. The clouds are usually so thick that the bottom parts are dark.

7. Air over the land may be warmer than air over the water. The air over the water moves downward and toward the heated air, pushing the warm air up. The movement of the cool air causes the breeze.

**Follow-up**

Encourage the pupils to watch the development of cumulus clouds and thunderstorms. They should notice the sequence of events in a thunderstorm and describe them to the class. Additional reading will help to account for some of the minor features of such a storm.

Some pupils may wish to investigate further the causes of the major winds of the world in encyclopedias and geography books.

## POSSIBLE LEARNINGS

Air expands when it is heated.

A given volume of cold air weighs more than the same volume of warm air.

Cold air tends to push up warm air and take its place.

The draught in stoves and fireplaces, and the circulation of air in a room, are usually due to the upward movement of warm air as it is pushed up by cool air.

Some surfaces become hotter in sunlight than do other surfaces.

Unequal heating of the earth's surface causes rising and falling air currents.

Many local winds are the result of unequal heating of the earth's surface.

Rising air currents cause certain types of clouds and local storms.

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*Everyday Weather and How it Works.* Herman Schneider. McGraw-Hill: Toronto, 1951. 189 pages.

Weather and weather forecasting.

*Let's Find Out.* Herman and Nina Schneider. S. J. Reginald Saunders: Toronto, 1946. 38 pages.

Air, heat, weather—a science picture book.

*Picture Book of the Weather.* Jerome Meyer. Ambassador Books: Toronto, 1948. 48 pages.

The author explains the forces that govern our atmosphere.

**Films**

*Story of a Storm.* Coronet.

Animation is used effectively to develop an understanding of the cycle of a local storm.

*Winds and Their Causes.* Coronet.

Air currents, thermals, thunderstorms, easterly and westerly winds.

# Water in the Ground

## PURPOSE OF THE UNIT

As stated in the introductory pages of the unit, the rain water that evaporates or runs away is gone, but the rain water that is in the soil performs many services. Pupils should know something of the mechanics of water movement in soil and rock. They should be acquainted with the factors that encourage rain water to enter the soil, and with the factors that restrain its entrance.

They should understand how ground water becomes polluted. They should know about the dangers of drinking from untested springs and wells. They should know how to treat untested water to make it safe for drinking. They should know how to arrange for tests of drinking water.

Conservation of ground water has become a major problem. On the one hand there are the increasing needs for water for home and industrial uses. On the other hand, there are decreasing supplies due to poor management, and increasing pollution due to lack of treatment of human and industrial wastes. In many areas, the level of water in the ground has dropped alarmingly. People must know more about maintaining and increasing present supplies of ground water.

The unit becomes a part of several major sequences that carry through the Exploring Science Series. Among these sequences are those on health, conservation, rocks and soil, erosion, chemical changes, plant growth, and interdependence of living things with their environment. The unit builds upon the work of previous units that give experiences with soil, rocks, solutions, acids and plant requirements.

## PREPARING FOR THE UNIT

The materials needed for the unit include an aquarium, a glass tube, sand, clay, some form of humus such as leaf mould or peat moss, and glass jars and metal cans of various sizes. Two glass tubes with a diameter of one inch or so, or two lamp chimneys, are needed for the experiment with the rise of water in soils as described on page 289.

If there are limestone caves in the vicinity, arrange a trip to visit one of them. Otherwise, collect pictures of caves. There are some excellent coloured photographs of caves.

It may be possible to see a well being drilled. Sometimes a talk by a well driller can be arranged.

One of the local health officers is usually willing to talk to the pupils about drinking water—how it is tested, and how untested water may be treated to make it safe to drink. He should show the procedures for collecting and sending samples to be tested. Local health ordinances may be discussed at the same time. A trip to a city water-treatment plant will show how water is made safe to drink.

List of Materials

- Tin cans
- Glass jars
- Hammer
- Nails
- Rectangular aquarium
- Sand
- Clay
- Garden soil
- Glass tubes
- Blotting-paper
- Glass panes
- Lamp chimneys
- Pans
- Slips of coleus or other house plants
- Limestone
- Liquid soap
- Humus or peat moss

## TEACHING THE UNIT

The unit is flexible. Its various topics may be taken up in any order. They may also be taken up at different times of the year should local situations make it desirable to separate the topics. Thus caves might be studied in the fall and well drilling in the spring. Such flexibility helps greatly in making it possible to use local resources effectively.

Try to introduce the unit with a study of some local feature such as a cave, a well being drilled, or a spring. Through this approach, the work of the unit is given more meaning, and many real problems are suggested for the pupils to solve.

**Page 277**

This page may be used to introduce the topic of drinking water. Raise the problems of how drinking water was obtained by people in the country many years ago and how it is obtained now. Most rural homes and many communities get their water from wells. A trip to see the well used by a community water system is worth while.

Communities that obtain their water from streams must be interested in the problem of ground water. Part of their water does come from run-off after rains, but in dry periods the water comes from springs. The pupils should realize that spring water is to be preferred because it contains less soil and the flow is more steady. Many cities that use the water from springs maintain forested slopes to increase the absorption of rain water and decrease the amount of run-off.

**Pages 278–279**

The problems of absorption and run-off were considered in the unit "Saving the Soil." They may be reconsidered now and given broader meaning. Experiments with the run-off from trays of bare soil and grass-covered soil may be repeated. The experiments may be varied to include the effects of forest litter and leaf mould. Slopes near the school may be watched during heavy rains to note the small run-off from grass-covered slopes and, if any slopes are bare, the large run-off from bare soil. The formation of puddles on level bare soil may also be noted and compared with the lack of puddles on lawns.

**Pages 280–281**

Soil drainage and the retention of water in soils is very important in the study of ground water. Numerous large pores in sandy soil permit the ready entrance of water. Clay, on the other hand, tends to prevent the entrance of water. From the standpoint of plant growth, a sandy soil is not ideal because it dries out too fast, but a clay soil is not ideal either because it does not drain well. Good agricultural soil contains both sand and clay. Experiments with various mixtures of the two might be tried at this time even though this diverges a little from the main thought of the unit.

The humus to be tested for water retention may be leaf mould, peat moss, or humus sold at garden stores. The humus should be crumbled up fine. It will probably be necessary to add water to dry humus slowly at first because dry humus does not wet readily. Once it has become damp, as it would be in soil, it absorbs water rapidly. Try various mixtures of sand and humus for water retention.

**Pages 282–283**

If the aquarium is large enough, make two ponds, one shallow and the other deep. After a few days of evaporation, the shallow pond will be dry while the other still contains water. Two wells of different depth can also be used.

If desired, the term "water table" can be introduced after the pupils have become acquainted with the concept of a soil saturated until all the pore space is filled. Too often, the term "water table" gains a wrong connotation through being introduced before the concept has been developed. Actually, the "water table" is just the boundary between the saturated and unsaturated regions.

It may be possible to take a trip to see some shallow ponds and marshes. If so, try to see them at several times of the year and note the changing water levels. In early fall, after a dry summer, many hollows are completely dry or nearly so. They may fill after spring thaws.

Pupils may wonder why the water levels in neighbouring ponds are different. A pond is there because under the soil at that point there is a layer of tightly-packed clay or of an impervious rock such as shale. The level of this impervious layer may be different under different ponds. It is like having two aquariums side by side but at different levels in the experiment on page 282. This also accounts for the reason why wells not far apart may be of different depths.

**Pages 284–285**

Open wells are not common any more and it may be difficult to see one, but a visit to such a well does help to make the concept of the saturated zone and the "water table" more vivid.

Try to show the pupils a well being drilled. The procedure is interesting and instructive. Wells are drilled in cities as well as in rural areas; city wells may supply water for air conditioning.

A well driller may be willing to give a short talk on the techniques used and on the conditions under which water is found. Some of these men can explain the occurrence of underground water very well. Others talk vaguely about underground lakes and underground streams and may confuse pupils, but their experiences are worth while.

The problems of pollution may be considered at this time. A local health officer should be contacted for information. He might be willing to talk to the pupils about pollution, safeguards, and testing methods. Health officers usually feel that this is part of their duty.

### Pages 286–287

Try to show the pupils some springs. There are usually springs wherever there are hillsides, even in cities, although the springs may flow only after heavy rains. Sometimes there are springs that have been dug out, built up with stones and concrete, and used as water supplies for cattle and even homes. Perhaps such a spring can be visited.

It is possible to simulate a spring in the aquarium. Above a sand layer put a thick layer of packed clay running nearly the length of the aquarium. Then build a hill of sand on this clay. The result should look something like a diagram on page 286. Sprinkle the sand with water and note the flow of water along the boundary between the sand and the clay. A spring "hole" may then be dug in the clay.

With the above model, the dangers from pollution may be more easily understood.

Below the water level on page 287 is a material which, like the shale on page 286, is impervious.

It should be realized by the teacher, and explained to interested pupils, that ground water moves slowly through such porous rocks as sandstone. It is possible to have springs emerging from sandstone and it is possible to drill satisfactory wells in sandstone, providing there is an impervious rock such as shale under the sandstone to keep the water in the sandstone.

### Pages 288–289

When the upper part of the soil becomes saturated during a rain, water flows down through the soil because of the pull of the earth. When the soil is not saturated, gravity plays little part in water movement. Much more important is the force that attracts water to such solids as glass and rock. The effect of this force can be seen at the surface of the water in a drinking glass where the water tends to creep up the sides of the glass. This force causes water to creep between the particles of soil, moving up, down, and sideways.

The demonstrations using blotting-paper and glass panes illustrate the effects of the force. Additional demonstrations can be used. A piece of cotton cloth partly immersed in water will become wet above the water level. Some weaves of cloth will actually empty a container of water if placed in siphon fashion over the edge of the container.

Two lamp chimneys of soil are shown in the demonstration on page 289. Perhaps two glass tubes of large diameter may be borrowed from a science department of a junior or senior high school if lamp chimneys are not available.

The soil should be dry at the beginning of the experiment. Motion upward in dry clay may be slower than in sand, but after a few hours the water reaches a higher level. Coloured water may be used.

Another demonstration illustrates the effect of the force. Fill a pan with fine soil that is nearly dry. Pour a few tablespoonfuls of water on the centre of the soil. After several minutes, the water will have moved outwards from the centre through the soil. If the soil is dug open, the effects of the downward creep can be seen also.

### Pages 290–291

An important point not made in the text is the active part of the plants in finding water. Not only does water creep from regions of comparative dampness to drier regions, but also the roots of plants are continually growing towards soil that has more moisture than the soil where the roots are. Generally, this root growth is downward, but if people water lawns and gardens lightly, so that the upper portion is the wettest, plant roots stay near the surface. This is not a good condition because plants are then less able to take care of themselves. It is recommended that when watering is done, the ground be saturated to a considerable depth.

Water in contact with fine particles of soil dissolves out minerals important to plants. These minerals are present in all soils but sometimes in insufficient quantities for good plant growth. Fertilizers contain these minerals for soils that are deficient in them.

The pupils may wish to test the effects of such minerals on house plants growing in soil. Results will be slower if the plants are already in rich soil. Plants that have been growing in the same soil for a year, however, may benefit from water that has percolated through rich soil several times. A soil rich in nitrates, such as soil with animal manure in it, gives quick and spectacular results with most plants. Experiments with so-called "plant foods," which are not foods but minerals, may be tried at this time, testing their effects on the same kinds of plants used in the above experiments.

### Pages 292–293

The amount of time given to a study of these pages should depend upon whether the local water is hard or not. In regions where the local water is soft there is little point in spending much time on hard water. Where the local water is hard, several lessons will be profitable.

To show that rain water dissolves limestone, it is suggested that a piece of limestone be broken up fine. Put the limestone in a heavy cloth before pounding it with a hammer, so that small bits do not fly in someone's eyes. Goggles like those used by mechanics may be used.

If no limestone is immediately available for the experiment, one may substitute broken shells or a little ground limestone sold at garden stores for "sweetening" the soil.

Liquid soap is used in most schools in soap dispensers. If none is available from this or a similar source, a bit of laundry soap can be dissolved in water but the process is slow.

A liquid detergent can be used for comparison with the effects of soap. With the detergent, the suds are usually as good in hard water as in soft water, and the cloudy material does not develop in the hard water as it does with soap.

In regions where there is hard water, many homes have water-softening devices. The water from such a device may be compared with unsoftened water and with rain water as described on page 293.

### Pages 294–295–296–297

Most pupils are interested in caves. They will enjoy studying how caves are formed, including types other than limestone caves. Encyclopedias and books on elementary geology give such information. They will also enjoy finding pictures and making bulletin board displays of the pictures. Some pupils may have visited caves and might like to tell about them.

Should there be a cave in the vicinity, arrange for a trip to see it. Most commercially developed caves give special rates to school children attending in a group.

### Page 298

Pupils who have visited regions where there are hot springs and geysers should be encouraged to tell about their experiences and show pictures which they have taken or purchased. Some children may wish to learn more about hot springs and geysers by reading encyclopedias and books on elementary geology.

### Summary Questions

1. The water coming from a spring may have fallen as rain on soil where there are harmful bacteria, or it may have come from the toilets of homes. Passage of water through soil does not necessarily eliminate the harmful bacteria.

2. The water in a well is water that soaked into the ground and filled spaces in the soil or rock.

3. Hard water is water that has certain minerals, usually those from limestone, dissolved in it.

4. The water level in soil becomes higher during periods of heavy rains. It drops during dry periods because some of it runs away in

springs, some is pumped out in wells, and some creeps to the surface where plants use it and where some of it evaporates.

5. Water that contains acid dissolves limestone. If this water trickles through cracks in limestone, the cracks are made larger and may reach the size of caves.

6. Water from wet regions of the soil creeps towards dry regions. During a dry season, much of the water that plants use comes to them this way. Also, plant roots are continually growing toward moister soil.

7. Plants need certain minerals in order to grow well. These minerals are taken into the plant with the soil water.

**Follow-up**

Some of the suggested experiences may not be possible at the time the unit is taught. These may be given at any later time that is convenient. Experiences given before a discussion make the discussion meaningful, but experiences given after a discussion are sometimes made more meaningful by the discussion. We should make use of as many experiences as possible, both before and after formal study of a topic.

## POSSIBLE LEARNINGS

Rain water soaks into different kinds of soils at different rates.
Humus and vegetation help soils to take up and retain water.
Water that enters soil usually flows down to a layer where it can go no farther, and then it fills the spaces in the soil.
The level of the water in the soil varies with the amount of rainfall and the factors that remove water from the soil.
Drinking water should be tested for harmful bacteria or it should be treated to make it safe to drink.
Water can move upward in soil during dry weather.
Some of the minerals dissolved in ground water are needed by plants.
Hard water is ground water that contains large amounts of certain minerals dissolved in it.
One must use more soap when washing with hard water, and it is more difficult to get things clean.
Ground water forms caves in limestone.
Ground water may be heated by hot rocks and come to the surface as hot springs or geysers.

## BIBLIOGRAPHY

**Books**

*Audubon Nature Bulletins.* Prepared and published by the National Audubon Society: New York. 4 pages each.

Several of the bulletins contain background information to supplement this unit. List sent by the Society on request.

*Handbook of Nature Study.* Anna Botsford Comstock. Thomas Allen: Toronto, 1947 ed.

Valuable for general reference and as a teaching guide. An up-to-date natural history library in one volume.

*Water for the People.* Sarah Riedman. Nelson, Foster & Scott: Toronto, 1952.

The story of water, with experiments and activities.

*Water Supply and Sewage Disposal.* Bertha Parker. Copp Clark: Toronto, 1949. 35 pages.

The story of New York City's water supply.

**Films**

*Limestone Caverns.* Coronet.

The action of water and air on rocks is shown and the formation of caves is explained.

*The Water We Drink.* Coronet.

The importance of pure water and how it is purified.

*Water in the Soil.* Encyclopaedia Britannica Films.

*Minerals and the Soil.* Encyclopaedia Britannica Films.

# Fish Life

## PURPOSE OF THE UNIT

The work of this unit leads toward three general subject-matter goals. The first, which is the most specific, is a better acquaintance with the major animal groups. Units in previous books of this Series have considered the other vertebrate groups and certain groups of invertebrates. Fish have been referred to on numerous occasions, but this is the first unit that deals with them specifically.

The second goal of this unit is the development of a better understanding of the interrelationships of living things and their physical environment. Several previous units have shown how one organism is dependent upon another, how an organism may be affected by the physical factors of the environment, and how organisms in turn alter the physical factors. The present unit builds directly upon the fifth-grade unit "Life in Quiet Water," but several other units contribute to the same outcomes.

The third goal, one that may be classified under the heading of conservation, is an understanding of the steps that must be taken to protect some of our natural resources. Although this unit deals with fish, the procedures for the conservation of fish apply to other things as well. Pupils should realize that there are two phases to the problem—study of the conditions that the fish need, and the co-operation of the general public in abiding by regulations needed to preserve these conditions.

Besides developing understandings, we wish to help pupils to develop desirable attitudes towards the problems of conservation. Boys and girls of this level should desire to abide by laws protecting natural resources. And they should be getting ready to work actively for the support of wild-life legislation when they become voters.

## PREPARING FOR THE UNIT

Teachers will find that there are usually many aids to teaching in their communities. For this unit, local sportsmen's associations may be able to give the greatest help. The members know the location of nearby fish hatcheries, exhibits, and displays. They can provide pamphlets and charts and posters. They can arrange for the showing of appropriate films. They can often help to arrange trips to see fish hatcheries, polluted streams, and protected streams.

It will be helpful to have one or more fish in the classroom for observation. Goldfish are satisfactory. It is to be hoped, however, that several local fish can be brought in. Native species from warm ponds and streams can survive in aquariums, but fish from swift streams usually need more oxygen than is available in ordinary aquariums. One should not collect species protected by law without a permit.

Specific teaching materials include one or more aquariums or large glass jars, an electric hot-plate, and a Pyrex cooking vessel or a Pyrex beaker.

**List of Materials**

Goldfish
Fish bowls
Rectangular aquarium
Pyrex beaker or saucepan
Electric hot-plate

# TEACHING THE UNIT

Build this unit around native species as much as possible. Men in local sportsmen's groups can give the names of the local species.

There may be some confusion over names of fish because the game fish in each locality are apt to be given local names. Bass are known in some places as "trout," and bullheads are known as "horned pouts" in many sections.

**Page 299**

The title page can be used to start pupils talking about their fishing experiences. Out of this discussion can grow a list of local fish and where these fish live. Pupils can ask parents for more information. A talk by a member of a sportsmen's association can add to this list. A map of the locality may be prepared to show the different types of habitats such as swift streams, slow streams, shallow or deep ponds.

**Pages 300–301**

In the study of the way fish swim, plan to have fish for the pupils to watch. Encourage them to keep records of their observations. Pupils may not appreciate immediately the high degree of co-ordination of swimming fish, but they can see many interactions of the fins.

Encourage the pupils to study the fins of several species of fish, looking at pictures and at real specimens for their information. They may make outline drawings of the fish and draw in the fins. They may attempt to correlate the position of the fins with some of the habits of the fish: for example, the pike, which darts after its prey, has its large fins at the rear of its body.

Many kinds of fish have air bladders. Such fish tend to rise when their fins stop moving and they float when they are dead. These fish float on their sides because the air bladders are located below the centre line of the fish. Direct the pupils to watch fish in an aquarium and notice the tendency of the fish to rise. If desired, a large fish can be dissected to show the air bladder.

**Pages 302–303–304–305**

The sunfish is chosen for a life history study because it is widespread, and because so many people know about it. However, there are regions where the sunfish does not live, and in such regions it is recommended that these pages be skimmed briefly to allow more time for the study of native species.

A few schools are fortunately located near ponds or sluggish streams where sunfish may be seen guarding their nests. Usually, however, the most that can be done is to call the attention of the pupils to the nesting habit and encourage the pupils to look for the nests when they visit such places.

The concept of sperms is introduced in this unit for the first time in the Exploring Science Series. Sperms may be compared with pollen of flowers. The egg when first laid is somewhat like the ovule of a flower; it cannot develop until it has been fertilized by a sperm, just as the ovule cannot develop until it has been fertilized by a grain of pollen. (There are exceptions to this statement among both plants and animals.) The concept of fertilization can be broadened to include other animals if the class seems ready for it. Toads and frogs, for instance, lay eggs and deposit sperms on them. In the case of birds, the sperms are deposited in the female just before the eggs are laid. Mammals and many insects also use internal fertilization. Pupils have usually noticed many examples of the mating process.

The care given to eggs by the parents varies greatly with the species. Some fish, such as the larger Pacific salmon, lay the eggs in places well removed from many enemies, but they give the eggs no further care. Other species, such as the sunfish, guard the eggs until they hatch. The stickleback builds an elaborate nest for its eggs.

The care given the newly-hatched young varies, too, but most species give no care to the young. Young fish are vulnerable to the attacks of numerous predators ranging from large fish to small water insects. Pupils can be shown, however, that only two young must survive during the lives of the parents to keep the population constant. With thousands of eggs being laid by one female each season, and with the female living several years, a high mortality among young fish is not to be regretted. Should all the young reach maturity our ponds would become overstocked in one season.

Perhaps a few young fish can be collected with a dip net and kept in a large aquarium. These young fish are tiny, they swim in "schools" and they are sometimes called "pinheads." In some regions all small fish are called "minnows," but the specialist considers minnows as being a particular family of fish. He calls young fish of any species "fry."

### Pages 306–307

Many of the larger fish are predators, capturing and swallowing smaller fish, frogs, salamanders, and the like. These fish have large mouths and sharp teeth. Pictures may show these characteristics but actual specimens are better. Fathers of children in the class may be fishermen themselves or know of other people who are, and they can usually provide a head of a predacious fish such as a bass, pike, or trout. It may also be possible to show the pupils some of these fish before they are cleaned. In either case, open the mouth of the fish and show the pupils the teeth.

Perch, sunfish, and many other smaller fish, feed on water insects which they take either from the surface of the water or from vegetation. The mouths of these fish are located near the front of the head. The mouths of killifish are slightly above the centre of the head.

Sunfish, among others, do well in the school aquarium. Keep one specimen in a large container with a plentiful growth of vegetation. Feed the sunfish tiny fish, tiny tadpoles, and small water insects, and small earthworms. The pupils will be able to observe the feeding habits of sunfish as typifying many other kinds of fish.

Suckers have mouths located on the under surface of the head. These fish feed on microscopic organisms and occasionally larger prey that they find on rocks, submerged logs, and the bottom material of ponds and streams. Suckers may be caught and brought in for the pupils to study, but they usually do poorly in schoolroom aquariums. It is better to observe them for a few hours and then return them to the place where they were caught.

### Pages 308–309

The oxygen supply is one of the most critical factors in the life of a fish. Whereas air is about one-fifth oxygen, water may contain only a few parts of available oxygen in a million parts of water. Air-breathing animals rarely have any problem in obtaining sufficient oxygen, but animals that take their oxygen from the water have a narrow margin of safety.

Temperature affects the ability of water to hold dissolved oxygen. Cold water can hold more oxygen than warm water and hot water contains little oxygen. The situation is comparable to a bottle of newly opened soda pop. If the pop is cold, carbon dioxide bubbles out slowly. If the pop is warm, the carbon dioxide bubbles out speedily and soon the pop is "flat" because little of the gas remains.

The experiment showing the effect of heat on dissolved gases is an important one. A metal container can be used, but the pupils must crowd round to see the bubbles form. A glass vessel, such as a Pyrex cooking-vessel or a Pyrex beaker, clearly shows bubble formation.

Pupils can see the gills of a goldfish as it opens its gill covers. If desired, a large fish can be dissected to show the gills. The head of a fish, which might be donated by a fisherman, can be used.

The diagrams at the bottom of page 309, show how a fish provides a flow of water past its gills. Water is sucked in through the open mouth when the fish moves the forward part of the gill covers outwards. The fish then closes its mouth and produces a pressure on the water by drawing the forward part of its gill cover inwards thus forcing the water out of the back of the gill chamber.

**Pages 310–311–312–313**

The limited supply of oxygen in water is usually replenished by direct absorption at the surface of the water. To a lesser extent, it is replenished by green water plants during the process of food making. The latter source is, of course, important only during daylight hours; the same plants withdraw oxygen from the water during the night. In bodies of quiet water, the upper layers may contain a maximum amount of oxygen while lower layers may contain but little. Any action that tends to circulate water, such as wind and currents, tends to distribute the oxygen-laden water to lower levels. Deep lakes, however, may be almost uninhabitable for fish in the deepest parts. Swift streams, on the other hand, have a uniform oxygen content at all levels.

As was mentioned before, temperature affects the amount of oxygen that can be dissolved in water. A rise in temperature may drive out dissolved oxygen and reduce the amount that can be absorbed from the air. Animals withdraw oxygen from water, but except in crowded conditions, as in an aquarium, the amount does not seriously deplete the oxygen content. More important are the processes which can make a pond or stream uninhabitable if enough decaying matter is present.

**Pages 314–315–316–317**

These pages apply the learnings of the preceding pages. The two factors that have ruined many streams for fishing are increased temperature and pollution. Elimination of pollution is partly a matter of legal control and partly one of educating the violators. Large industries and large cities are the most serious offenders, but a small community or factory can ruin a stream with its sewage and wastes.

The problem of keeping streams cool is a more difficult one to solve because so much land must be kept open for agriculture. Only in hilly regions is a dense forest cover economically feasible. However, education of land owners may make them realize that trees and brush along streams reduces erosion and flood damage.

The same principles apply to the stocking of aquariums. An ideal aquarium has a large surface area for the absorption of oxygen from the air. An aquarium should be kept in a cool place so that the water does not become heated and lose its oxygen even for a short period during the day. Overstocking of the aquarium should be avoided to reduce the drain on the dissolved oxygen. Decaying materials such as dead plants and animals, uneaten food, and faeces should be removed as soon as possible. Some scavengers such as snails help to remove such debris, but they cannot take care of large amounts rapidly.

### Pages 318–319

Take the pupils to see a fish hatchery if there is one near the school. Parents will frequently co-operate by doing the driving. It may be possible to arrange the trip at the time when the fish are being "stripped" of eggs and sperms. One must keep in touch with the director or superintendent of the hatchery to learn the best date for the trip. It is not necessary that the trip be taken during the teaching of this unit; it may precede or follow.

### Pages 320–321

Bullheads and their relatives are common through much of our country. A study of their life histories will interest most pupils. Try to show the pupils a large specimen so that they can see the spines, the barbels or "feelers," the small eyes, and the lack of scales. A small bullhead can be kept successfully in an aquarium. Its oxygen demands are low and it will eat foods such as small worms and fish food.

In addition to the dorsal fin, each of the pectoral fins (just behind the gill covers) has a stiff, sharp spine. This spine is at the front of each fin.

### Pages 322–323–324

A study of fish is not complete without reference to the migrating habits of fish. Much of the migration goes unnoticed, being a movement towards the shores or headwaters of streams by fish who normally live near the breeding grounds. Sometimes, however, the migration is spectacular and challenging to the imagination, as is the case with the great "runs" of Pacific salmon. It is essential that migration habits be understood because frequently the conditions met during migration are the ones that determine the success or failure of a species.

#### Summary Questions

1. Most fish are meat-eaters and feed upon smaller animals. A few are vegetarians or omnivorous in their diet.

2. A fish egg cannot develop unless a sperm from a male of the same kind of fish enters the egg.

3. Oxygen goes into the water at the surface. Some is added by plants as they make their food during daylight hours.

4. A fish takes oxygen from water through its gills. The oxygen passes through the thin skin of the gills into the blood within.

5. Garbage and sewage take oxygen from the water and may remove so much that fish cannot live in streams polluted by it.

6. The pupils should mention the coolest place in the classroom, avoiding places near a radiator or in direct sunlight.

### Follow-up

Continued observation of fish in aquariums represents an interesting follow-up. This is especially valuable when native species are kept. Once people understand that the class is interested in fish, they will frequently bring in specimens. These may be discussed briefly and returned or discarded.

Additional trips to fish hatcheries, aquariums, fish markets, and the like may suggest themselves. These trips are valuable even after formal study of the unit has ended.

## POSSIBLE LEARNINGS

Different kinds of fish have different kinds of fins.
Many fish contain an air bladder that helps them to float.
Most fish are meat-eaters although some feed on plants as well.
A fish egg cannot develop unless a sperm enters it.
Some fish take care of their eggs.
Fish take oxygen from the water through their gills.
Water loses dissolved oxygen if it is heated.
Decaying things remove oxygen from water.
Oxygen enters water at the surface.
Green plants give off oxygen while they are making food.
We can often improve fishing by keeping streams and ponds cool, and by eliminating pollution by sewage, garbage, and chemicals.
Some fish migrate for egg-laying.
Fish vary greatly in their needs.

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### Books

*Fishes.* Bertha Parker. Copp Clark: Toronto, 1941. 35 pages.
The life cycle of fishes, their homes, food, self-protection, and usefulness to man.

*Goldfish.* Joy Buba. George J. McLeod: Toronto: 1947. 64 pages.
Answers many questions simply and scientifically.

*Reptiles, Amphibians and Fishes.* Charles Eifrig. W. J. Gage: Toronto, 1951. 249 pages.
A book designed to furnish information and stimulate natural interests. Contains information on a school aquarium.

*Wonder World of Fishes.* Ida Mellen. Dodd: Toronto, 1951. 160 pages.
Interesting information on fish, their habits, and habitats.

**Films**

*Field Trip to a Fish Hatchery.* Coronet.
A class takes a field trip to a fish hatchery to answer some questions about the development of fish and the purpose of hatcheries.

*Sunfish.* Encyclopaedia Britannica Films.
The life of the sunfish showing the laying and fertilization of the eggs, hatching of the eggs, and the development of the fish to maturity.

# Trees

## PURPOSE OF THE UNIT

Today we recognize that trees are a major factor in the environment. At one time, trees were considered valuable chiefly for the lumber that could be made from them. Little thought was given to their other contributions. We have since learned some expensive lessons, but fortunately a few far-seeing men took steps to educate the general public before our forests vanished completely.

This unit stresses certain factors that affect the growth of trees and the maintenance of forests. It sets the stage for intensive study in higher grades of the problems of forest conservation. It should make pupils conscious of conditions that affect the value of trees for lumber. It can be extended to point out the value of trees in recreation. It should help pupils to appreciate the importance of forests in protecting our watersheds.

Helpful concepts are developed in such previous units as the third-grade unit "Muddy Water," the fourth-grade unit "Soil," the fifth-grade unit "Streams at Work," and the sixth-grade units "Saving the Soil," "Water in the Ground," and "Fish Life." Other concepts helpful in understanding how forests can be protected are developed in the third-grade unit "Fire and Air," the fifth-grade unit "Controlling Fires," and the sixth-grade unit "Plants That Are Not Green."

It is to be hoped that from this study pupils will gain an increased interest in individual trees and in forests. There are many things that boys and girls can do and can avoid doing to help to protect this valuable natural asset.

## PREPARING FOR THE UNIT

Although this unit is assigned to the spring season in this book, it may be advantageously treated in any season. Sometimes local conditions, such as a forest fire, or a tree-planting project would make the unit appropriate at some time other than spring.

Before introducing the unit it is wise to look about the neighbourhood for trees that illustrate some of the points considered here. Young pines and spruces, naturally seeded or planted, will show how trees of this type grow. Some of them may show the effect of injury to the main leader. Saplings that spring up in hedgerows, vacant lots, and untended gardens give material for study of new growth. The stump of a felled tree permits the pupils to study the annual rings. Most young trees and many older ones show injuries partially and completely healed. Many of the older trees show rot that began where large limbs were cut or broken off.

There may be interesting examples of forestry practice near enough for field trips. A trip to see a fire tower and listen to a ranger tell about fire-control methods is often possible. A trip to see a tree plantation and listen to the problems of local forestry as related by a state or national forester may be arranged. Plan a trip to a sawmill.

List of Materials

Twigs of local trees
Scraps of lumber showing grain and knots

## TEACHING THE UNIT

Try to utilize some local event or feature to introduce the study of trees. This might be no more than a freshly cut stump which can be visited to count the growth rings, or it might be a disastrous forest fire that has made the headlines of the newspapers.

Build the unit round local features as much as possible. Short trips may be taken to see a hollow tree, or to count the rings in a stump, or to notice the leaders on spruce trees. Longer trips require transportation, either a school bus or the cars of interested parents.

The word "parasites" has been set in bold face on page 334, the only special science word in this unit. The teacher may wish to mention, at this time, another sense in which this word was used in Book Five, namely animals, instead of plants, as parasites.

Extensive readings in the problems of conservation should attend this unit. Better readers can read some of the more advanced books and slower readers can read some of the large number of bulletins written for children. Reports on these readings serve to bring about an exchange of information and to initiate discussions.

**Page 325**

This title page can be used to begin a discussion of the uses of trees. From the picture, pupils should recognize the use of trees for lumber, for fruit, for shade, and for recreation. They should recognize the value of the forests on the mountains in the background as holding soil and retaining moisture. With these points in mind, the pupils may begin extensive lists of the uses of trees, including both the uses of living trees and the products of felled trees.

The value of forests in holding soil on steep slopes and in retaining moisture should be considered at some length, reviewing and expanding concepts previously considered in earlier units.

**Page 326**

New growth on saplings is easily noted because of the contrast in the colours of the bark. If many different kinds of young trees can be found near the school, a short trip to see some of them should be taken. After several kinds are studied, measure the new growth on all the twigs of a small sapling. Add the length of these growths together to obtain the total growth of the upper part of the tree. Point out to pupils that even more extensive growth is underground.

If a trip cannot be taken, a specimen may be brought in for study.

**Page 327**

Bring in some twigs of valueless saplings or trees. Peel off some of the bark and show the pupils the growing region under the bark.

Try to obtain a section of a small log to show the pupils the annual rings. Such a section may be sandpapered and waxed to make the rings more prominent. Ash, certain southern pines, and sumac have sharply contrasting rings of spring and summer wood.

If a large tree is cut down near the school, visit the stump and count the rings. Connect the age of the rings with local and national events.

**Pages 328–329**

Leader growth is typical of such evergreens as pines and spruces. Spruces in particular are used as ornamental shrubs about buildings and are usually available for study. Show the pupils the present leader and the lateral twigs that grew from the top of last year's leader. If new buds have developed, point these out to the pupils and try to determine which will become the new leader.

Determine the age of some of the smaller trees by counting the spaces between the whorls of side branches. The trees are probably a year or two older than the calculated age because the lateral branches formed during the seedling stage may have died.

Try to find trees that have lost their central leaders at some time in the past. Note whether one or two lateral twigs became leaders. Determine the year when the central leader died by counting the spaces between the whorls of branches above it. Examples of trees showing these effects are best found in plantings of evergreen trees.

Use tree guides to identify the trees that are studied. If the trees are ornamental, a landscape gardener and catalogues of ornamental trees can help in identification.

**Pages 330–331**

The shape of a tree depends partly upon its inheritance and partly upon the conditions under which it grows. Trees growing in open fields usually have distinctive shapes and many people come to know such trees as elms and white pines by their appearance at a distance. Encourage the pupils to identify the trees of the vicinity and learn their characteristics. Some pupils like to make drawings of tree shapes. Others may make a hobby of photographing the trees.

A factor that affects tree shape in great degree is the amount and direction of light. Some of the experiences suggested in the fifth-grade unit "Plants and Light" can be reviewed and repeated if desired. Try to visit a dense wood to notice the effect of crowding on the shape of trees. Show the desirability of tall, limb-free trunks for lumber.

**Pages 332–333**

These pages point out briefly the importance of leaves to trees, a concept introduced in the fifth-grade unit "Plants and Light." These pages also indicate that trees can be identified by the shapes of their leaves. Many pupils will enjoy learning to identify local trees by means of the leaves. Use field books for reference.

An interesting project is to make a map of the neighbourhood surrounding the school. The trees of the area, particularly those along the streets, may then be identified and labelled by symbols or colours.

Nearby parks usually have several kinds of trees. Often these are labelled or numbered and may be used in identification games.

Some pupils may wish to collect leaves and preserve them. The leaves should be dried between blotters and mounted with bits of gummed tape. Other pupils may wish to make leaf prints. For ink prints, spread mimeograph ink evenly on a pane of glass, lay the bottom side of the leaf in the ink, and then press it against a sheet of mimeograph paper. Spatter prints are made by laying a leaf on a sheet of construction paper, weighing it down with small pebbles to keep it flat. Then a toothbrush is dipped in coloured ink or poster paint and rubbed on a bit of screen held over the leaf to make a spray of tiny drops that spatter on the paper about the leaf.

### Pages 334–335

Diseases caused by plant parasites are common on trees but most of the diseases are not fatal. The pupils will find the spore-bearing parts of many of these plants if they examine the trees about them. Most easily recognized are "shelves" of bracket fungi as on page 334.

If it is possible to talk with a tree service representative, he will describe or point out the effects of common parasites. Agricultural agents and foresters can also give help with this topic. If there is enough available material, make an exhibit of evidences of parasites on trees, using bracket fungi of different kinds, cedar "apples," twigs killed by white pine blister rust, black knot of plums, and wood showing the work of the grubs of Dutch elm beetles.

### Pages 336–337

The best way to show pupils how trees heal their injuries is to visit trees in the neighbourhood and find examples of various stages of healing. Trees from which low branches have been cut show the effect clearly. See where trees have been hit by lawn mowers or cars.

Sometimes it is possible to find a tree from which a large branch has been removed several years before. Usually the exposed wood has decayed to some extent, often leaving a cavity.

If possible, arrange for a representative of a tree service company to describe the work done in preventing decay in trees.

Pupils should not think of decay in trees as being completely unwanted. Many animals utilize these cavities. Some birds such as bluebirds, starlings, and wrens nest in the smaller cavities. Screech owls and wood ducks nest in larger cavities. Squirrels and raccoons use hollows in trees as dens. Many insects spend the winter in cavities in trees.

### Pages 338–339

These pages are greatly enriched by a trip to see logging operations and a sawmill. Small-scale operations, and small mills, are more easily comprehended than large operations. Be sure the pupils notice the great amount of waste involved in the production of lumber. One of our problems today is in making better use of this waste matter.

Call attention to the way that boards are usually sawed from a log. At a sawmill the reasons for this practice are quickly obvious because the centre boards are seen to be full of knots and the outer boards have fewer knots or sometimes none at all. If the children do not know what knots are, show them some knotty boards and refer them to page 341.

### Pages 340–341

Call the attention of the pupils to the grain in boards in the room—in desks and chairs. Bring in boards to show grain and to show the annual rings in the ends of the boards. For this purpose, cheap lumber from crates is suitable. Many such boards will also show knots.

Workers in lumber yards and teachers of woodshop courses can give help in explaining the causes and the differences of grain in lumber. They can also supply samples for a lumber collection.

### Pages 342–343

The map on page 342 shows the general distribution of forests in the early days of Canada's history. Of course there were small open areas in much of the region indicated as forested and there were small plots of trees in the regions indicated as unforested, but these exceptions are too small to be shown on the map.

The same is true of the map on page 343 which shows the extent of commercially valuable forests in recent times. Some of the areas, cut some years ago, now have second-growth woodlands; but the stands of large timber are too small to be shown, and the second-growth trees are so young they cannot be considered as forests in the commercial sense.

During discussion of these pages ask the pupils to list the causes for deforestation. Besides lumbering activities, they should mention forest fires, the effects of diseases, and windstorms. The pupils may then consider in more detail the causes for forest fires which range from lightning to carelessness with cigarettes and campfires. They may also read about and report on some of the serious tree diseases.

### Pages 344–345

To enrich the study of these pages, encourage the pupils to read some of the many pamphlets and books written on forest conservation. They may take up different aspects on an individual or small group basis and report their findings to the class. It may be possible to invite a conservation expert to speak to the class on this phase of the unit. Local foresters, agricultural agents, representatives of sportsmen's organizations, and teachers of conservation courses are often willing to speak to the class or to large groups of pupils in general assemblies. Many of these men are trained in speaking to such groups and they usually supplement their talks with moving pictures.

### Page 346

The planting of small trees for shade, ornament, or fruit is something most home-owners should understand. The techniques described here are the ones generally accepted for most trees. Catalogues of shrubs and trees give more extensive directions. They also give advice about attaching guards to protect the trees and guy wires to hold the trees upright until the roots have anchored the trees securely.

### Summary Questions

1. A tree grows larger in two ways. The twigs grow longer at their ends. The trunk and twigs grow larger in diameter by adding layers of wood under the bark.

2. The grain in a board is caused by sawing lengthwise through the yearly growth rings.

3. Leaves produce the food that trees need.

4. Trees are important to us in two general ways. Living trees provide shade, ornament, fruit, shelter for animals, shelter from wind, and serve in many kinds of recreation. They also help to hold the soil on slopes, they reduce the run-off from rains and melting snows, and they keep the soil and the streams cool in summer. Trees are also useful for lumber, paper pulp, and many other products.

5. Our forests have been destroyed by extensive—and wasteful—cutting, by fires, by diseases, and by storms.

6. A boy or girl can help to prevent forest fires by being careful with campfires and matches.

7. We are trying to conserve our forests by preventing fires and diseases. We have set aside some forests on the headwaters of streams

where they cannot be cut. We are experimenting with ways to make better use of our present forests. We are planting new forests.

**Follow-up**

Follow-up for such a unit consists of taking advantage of those situations as arise unexpectedly. Some additional examples illustrating points already considered may be found. Perhaps a speaker on a conservation topic or a conservation film may become available. These opportunities should be utilized even though the unit has already been ended. They serve for review and for re-application.

## POSSIBLE LEARNINGS

Trees grow by lengthening and enlarging their trunks and twigs.
The shape of a tree depends partly upon its kind and partly upon the conditions under which it grows.
Trees are injured by parasites, animals, fires, winds, and man.
Man makes many uses of trees.
We have cut a large share of our natural forests.
We must use our remaining forests carefully and take steps to restore them to a more usable condition.

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A reliable guide to American trees.

*First Book of Trees.* Maribelle Cormack. Ambassador Books: Toronto, 1951. 93 pages.
Teaches identification of trees and some of their processes.

*Thanks to Trees.* Irma Webber. S. J. Reginald Saunders: Toronto, 1952. 60 pages.
A story on conservation.

*Trees.* Herbert Zim and Alexander Martin. Musson: Toronto, 1922. 160 pages.
A guide to familiar American trees.

*Trees and Trails.* Clarence Hylander. Brett-Macmillan: Toronto, 1953. 237 pages.
A geography of trees. Gives the life story of a tree.

*Native Trees of Canada.* Department of Mines and Resources, Ottawa.

## Films

*Use of Forests.* Coronet.

Forest areas of our country are visited and uses of wood and wood products are shown.

*SN-30 Forest and Conservation.* Ontario Department of Education.

This is an important film for the study of the critical problem of how to conserve and efficiently utilize our forest resources.

*Making the Most of Your Woodlot.* National Film Board.

# List of Science Materials

## *(Class of Thirty Pupils)*

| QUANTITY | ITEM | REMARKS |
|---|---|---|
| 2–15 | hand lenses | low power |
| 2–15 | thermometers | household type |
| 1–2 | aquariums | rectangular, medium size |
| 2–15 | dry cells | standard 1.5 volts |
| 200 ft. | insulated wire | No. 24 nylon- (or double cotton) covered |
| 2–4 | magnetic compasses | two-inch diameter |
| 2–4 | electric bells | to operate on dry cells |
| 2–6 | awning pulleys | single sheave, also double sheave if available |
| 1–3 | tuning-forks | different pitches |
| 1 set | wire guitar strings | four strings for standard guitar |
| 1 | electric hot-plate | |
| 1 | electric lamp | |
| 1 | electric fan | may be borrowed |
| 1 | flashlight | may be borrowed |
| 4 | alarm clocks | may be borrowed |
| 1 | funnel | small; glass or metal |
| 1 | Pyrex beaker | large, or one-quart pan |
| 2–4 | lamp chimneys | small diameter |
| 2–10 | one-hole stoppers | to fit bottles |
| 2–10 | pieces glass tubing | to fit stoppers |
| 1–2 | lengths rubber tubing | to fit glass tubing; two feet long |
| 2–12 | rubber balloons | |
| 1–15 | balsa wood sticks | 12″ × ¼″ × ¼″ for model planes |
| 1 | record player | may be borrowed |
| 1 | record | discarded or nearly worn out |
| 1 | shovel | small |
| 2–6 | hammers | light claw |
| 1 | saw | cross-cut |
| 1 | tape measure | thirty foot |
| 2–4 | metal shears | good quality |
| 2–6 | pliers | side-cutting preferred |
| 2–15 | screwdrivers | small, assorted sizes |

| QUANTITY | ITEM | REMARKS |
|---|---|---|
| 2 | nail sets | |
| 2–15 | scissors | |
| 2–4 | coping saws | |
| | nails | assorted, including spikes |
| | screws | assorted, round and flat heads |
| | tacks and brads | |
| | screw eyes | small |
| | split copper rivets | small |
| 2–6 | bolts and nuts | large, for demonstration |
| 1 | tube airplane cement | quick setting |
| | needles and pins | |
| | candles | plumbers (large ones) |
| | thread | |
| | string and cord | |
| | thumb-tacks | |
| | paper clips | |
| | brass paper fasteners | |
| | soda straws | |
| | mailing tube | |
| | thin cardboard | Bristol board |
| | tracing paper | |
| | cards | |
| | paper bags | five-pound size |
| | drawing-paper | both black and white |
| | blotting-paper | |
| | rulers | |
| | rubber bands | |
| | modelling clay | |
| 8–15 | drinking glasses | |
| 2–3 | plates | |
| 1 | bowl | |
| | tin cans | assorted |
| | glass jars, bottles | assorted |
| | plant pots | assorted |
| 2 | pans | shallow; pie tins satisfactory |
| 2–15 | spoons | |
| 1 | paring knife | |
| 2 | glass panes | about 4″ × 4″ |
| 1 | book end | |
| | boards | assorted |
| | scraps of lumber | |

| QUANTITY | ITEM | REMARKS |
|---|---|---|
| 2 | wooden boxes | |
| | round sticks | dowels or broom handles |
| | screening | for ends of erosion trays |
| | heavy roofing paper | for bird houses |
| | bare copper wire | short pieces |
| 12 | marbles | |
| | small beads | |
| | musical toys | |
| | discarded nail files | hack-saw blades can be used |
| | sand | |
| | topsoil, subsoil | |
| | garden soil | |
| | woods soil or peat moss | |
| | limestone | ground limestone can be used |
| | feathers | any type of bird feathers |
| | old bird nests | |
| | chicken bones | |
| 1 | yeast cake | fresh |
| | oranges | |
| 1 | lemon | |
| 2 qts. | vinegar | |
| 2 lbs. | baking soda | |
| | cream of tartar | |
| | tomato | |
| | grapefruit | |
| 4 oz. | liquid soap | |
| 5 lbs. | wheat flour | |
| 2 | small goldfish | |
| 2–8 | house-plant slips | coleus slips excellent |
| 1 | globe | |
| | weather maps | from a newspaper |
| | time zone map of Canada | |
| | almanac | |
| | calendars | of successive years |

# General References for the Teacher

*Audubon Nature Bulletins.* Prepared and published by the National Audubon Society: New York. 4 pages each.

These bulletins contain background information and teaching suggestions for nearly every topic. Consult list of titles.

*Cornell Rural School Leaflets.* Prepared and published by Cornell University: Ithaca, New York.

These leaflets contain background information and teaching suggestions for nearly every topic. Consult the list of titles.

*Fieldbook of Natural History.* E. Laurence Palmer. McGraw-Hill: Toronto, 1949. 664 pages.

Condensed information on a wide variety of plants, animals, rocks, and minerals.

*Golden Treasury of Natural History.* Bertha Parker. Musson: Toronto, 1952.

Interesting background information for the teacher.

*Handbook of Nature Study.* Anna B. Comstock. Thomas Allen: Toronto, 1947 ed. 937 pages.

Excellent reference on common plants and animals, together with teaching suggestions.

*Man in Structure and Function.* Fritz Kahn. McClelland and Stewart: Toronto, 1943.

A beautifully illustrated work on the human body written in a clear understandable style. There is an excellent chapter on alcohol and tobacco.

*Elementary School Science and How To Teach It.* Glenn O. Blough and Albert J. Hugget. Macmillan of Canada, 1951.

Among the main headings are: The Earth and the Universe; Living Things; Matter and Energy; Conservation of Our Resources; Fire and Prevention; The Behaviour and Habits of Animals.

*Nature Notebook.* Robert Candy. Thomas Nelson: Toronto, 1953. 114 pages.

Detailed, accurate information about life in woods and streams and notes on outdoor crafts enrich a father-and-son field trip. Beautifully illustrated by the author.

*Science for the Elementary-School Teacher.* Gerald S. Craig. Ginn: Toronto, 1947.

Background information on a variety of science fields, together with specific suggestions for teaching the material.

*Making and Using Classroom Science Materials in the Elementary School.* Glenn O. Blough and Marjorie H. Campbell. Macmillan of Canada, 1954. 229 pages.

A practical book with descriptions of appropriate activities including photographs and drawings and carefully prepared lists of source material.

*Natural Science Through the Seasons.* J. A. Partridge. Macmillan of Canada, Revised Edition, 1955.

A practical and informative text for teachers of Grades I–VI.

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Jam Handy. General Films Limited, 18 Breadalbane Street, Toronto.

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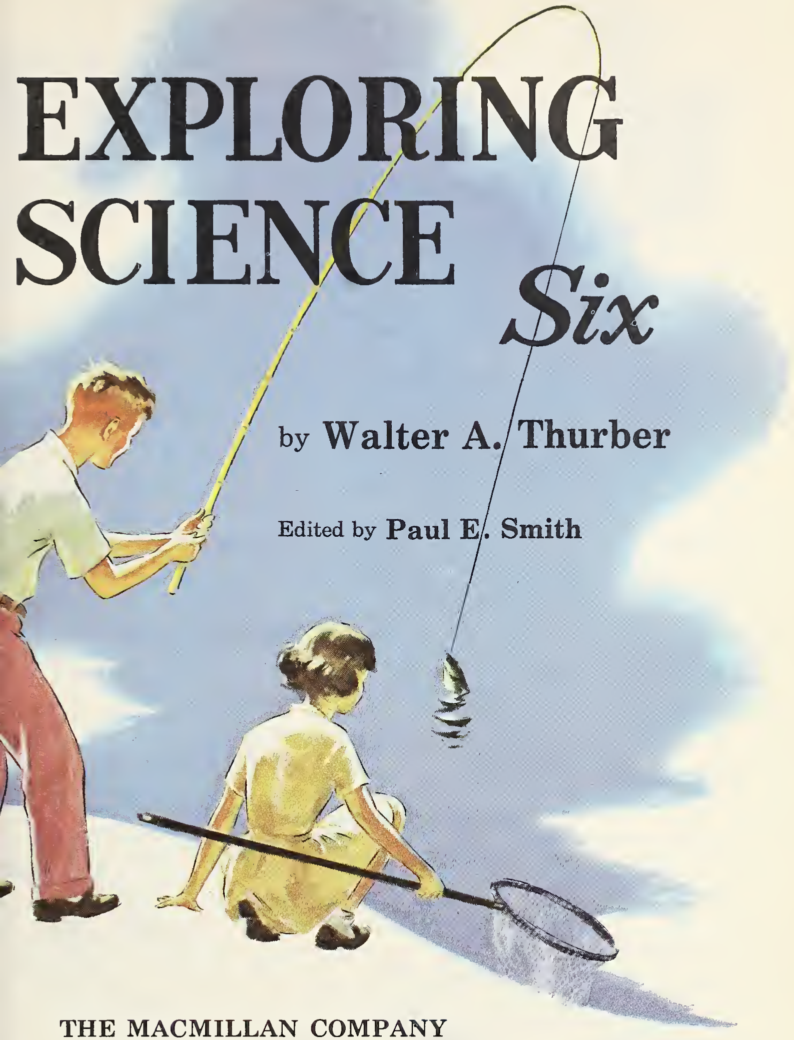
# EXPLORING SCIENCE *Six*

by **Walter A. Thurber**

Edited by **Paul E. Smith**



THE MACMILLAN COMPANY
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TORONTO

# EXPLORING SCIENCE SERIES

*One · Two · Three · Four · Five · Six*

READING
CONSULTANT

**Linda C. Smith**

Revised Canadian Edition

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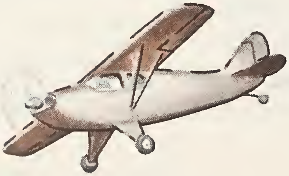
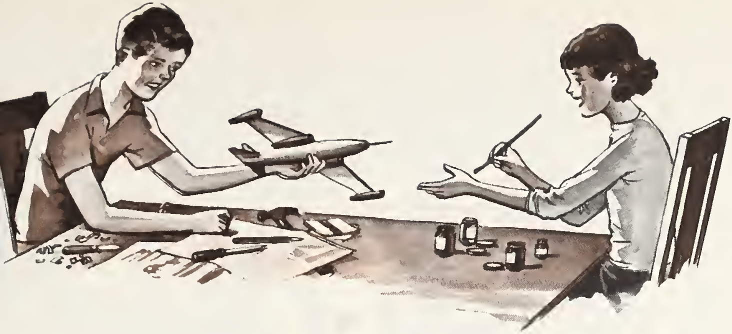
*Printed in Canada*





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*Illustrated by*
**Philip B. Parsons**
**Charles E. B. Bernard**

# Plants That Are Not Green

## Finding Mushrooms

There are many plants that are not green. Betty and Mary found some of them on a walk in the woods one day.

"Look at the mushrooms," Betty said, pointing to some yellow plants growing among the dead leaves on the ground.

"There are more of them on that log," said Mary.

"They look a little like shelves."

Betty pointed to other mushrooms growing on a tree trunk.

"Mushrooms can grow on live trees, too," she said.

## Spores of Mushrooms

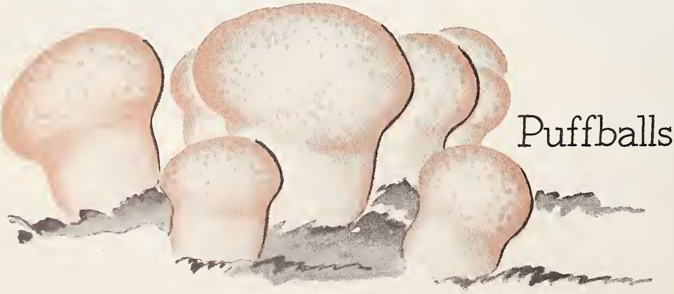
Betty found a mushroom that was shaped somewhat like a ball.

Mary said, "I know what that is. Pinch it."

Betty pinched the mushroom. The top popped open and out shot a cloud of brown dust.

"That's a puffball," said Mary.

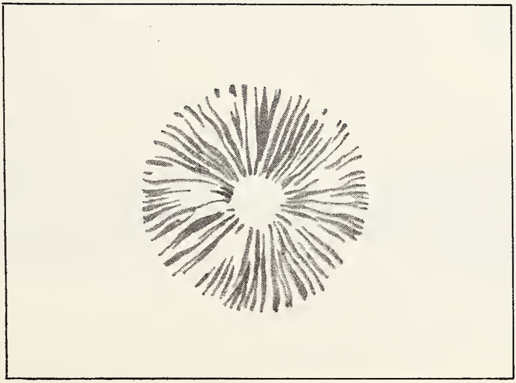
The brown dust that came from the puffball was made of **spores**. Spores are somewhat like the seeds of other plants. Each spore can grow into another puffball plant.



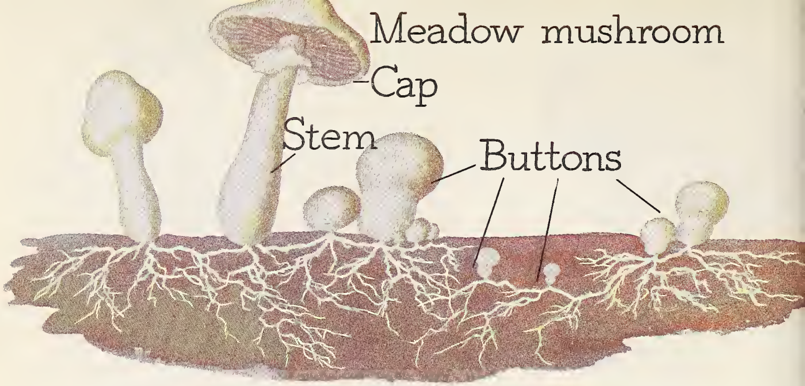
Other mushrooms have spores, too. Find a newly opened mushroom like the one shown above. Cut off its stem and lay the top part on a sheet of white paper. Cover it with a drinking glass and leave it overnight.

Then take away the glass and lift the top of the mushroom very carefully. You should see on the paper a print that looks like the underside of the mushroom. The print is made of spores that fell from the mushroom.

All mushroom plants grow from spores. The spores blow from the mushrooms. If a spore is blown to a place where it can grow, it grows into a new plant.



Spore print



## What Mushrooms Are

A mushroom is only a part of the mushroom plant. It is somewhat like the fruit of other plants.

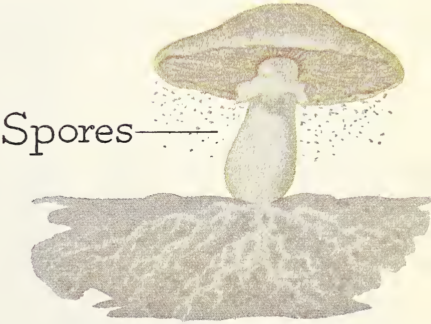
Most of a mushroom plant is hidden. It does not need light as green plants do. You can find the plant by digging around a mushroom. The plant looks like a mass of white, shining threads.

At times, little "buttons" begin to grow on the threads. These buttons grow rapidly. Sometimes they grow up out of the ground in a single night.

Then the buttons open and the caps spread out. There are millions of spores in each cap. The spores fall out and blow away. Each spore can become a new plant if it lands in a place where it can grow.

2

4



6

A log five years after falling

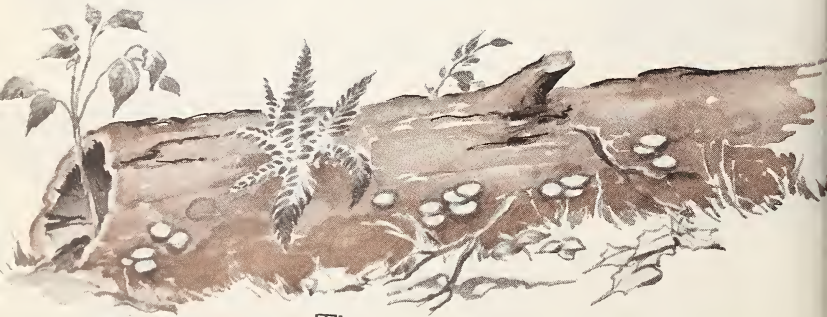
## The Food of Mushroom Plants

Mushroom plants cannot make their own food. Green plants can use water, air, minerals from the soil, and energy from sunlight to make food, but mushroom plants must get their food from other things.

Most mushroom plants get their food from dead plants. Many of them live in dead wood. Others live in soil that has dead leaves, stems, and roots in it.

These mushroom plants are important. They break up dead plants and change them into rich soil. Green plants need this kind of soil.

Visit a woodland. Look for tree trunks and piles of leaves that are changing into soil. Collect some of the soil and study it with a hand lens.

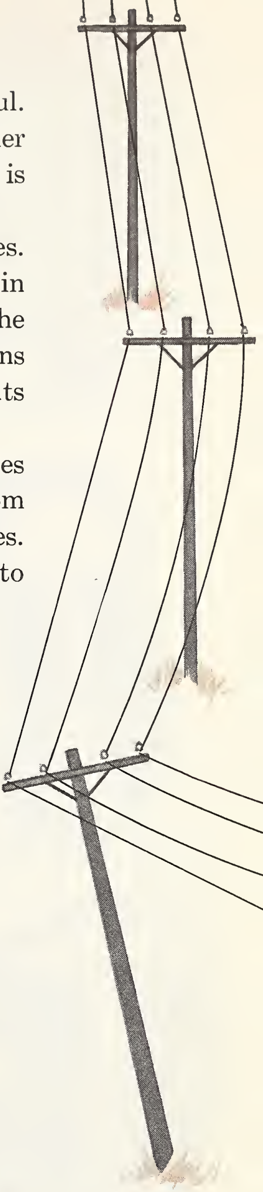


The same log ten years later

Mushroom plants can also be harmful. Some kinds grow in living trees. Other kinds live in logs and lumber if the wood is damp.

We must often put wood in damp places. Fence posts and telephone poles are set in holes in the soil. Railroad ties lie on the ground. Floor beams of houses and barns are near the soil. When mushroom plants grow in this wood, they weaken it.

Wood used in damp places is sometimes soaked in chemicals that kill mushroom plants. Look at some telephone poles. Notice the black chemical that is used to keep them from decaying.



Fly Amanita

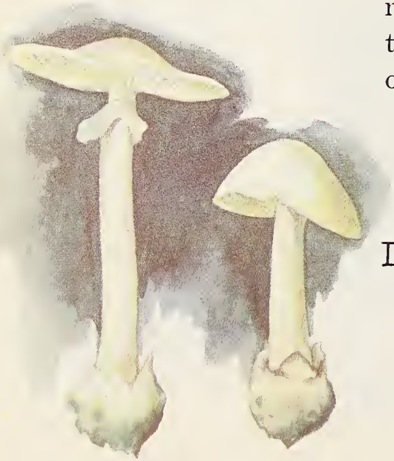
## Poisonous Mushrooms

Some kinds of mushrooms are deadly poison if a person eats them. There are other kinds that make a person very sick.

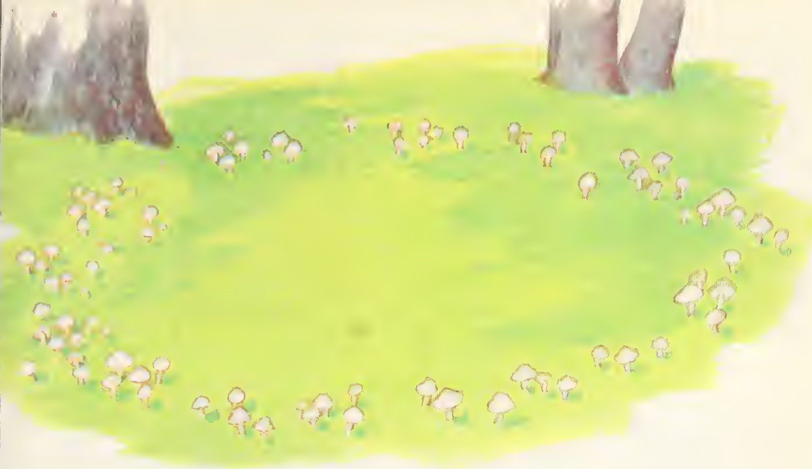
The mushrooms you buy in stores are safe to eat, but it is not wise to eat wild mushrooms unless you know which ones can be eaten without harm. There are no rules that will help you tell a poisonous mushroom from a safe mushroom. You should never eat mushrooms that you do not know about.

Poisonous mushrooms will not harm you if you touch them. They are dangerous only if you eat them.

Destroying Angel



Deadly Amanita

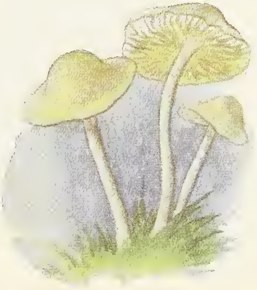


## Fairy Ring Mushrooms

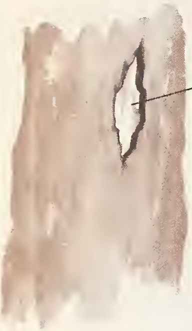
These interesting mushrooms grow in circles on lawns and pastures. People have wondered about them for hundreds of years and they have made up stories about them. Some people once believed that the rings were places where fairies danced at night. They thought it was lucky to have them on their land.

Today we believe that a fairy circle started from a single spore. Each year the plant grows outward a little farther. The mushrooms grow only on the outer part of the plant.

You may not find rings that go all the way around. More often you will find parts of rings.

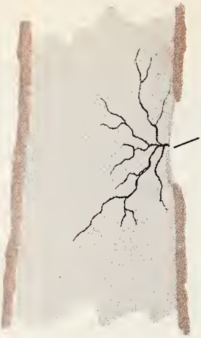


Fairy Ring mushrooms



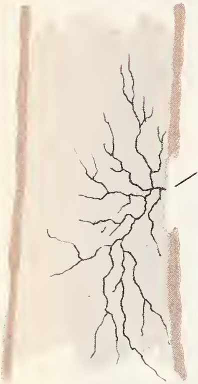
1

A spore falls in a wound in the bark.



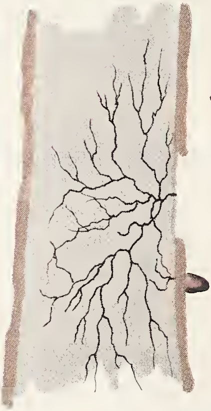
2

The spore begins to grow in the wood of the tree.



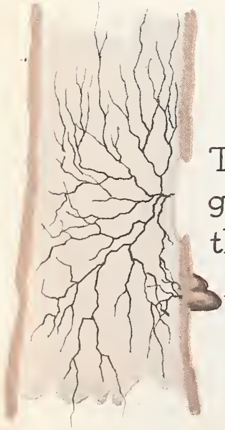
3

The mushroom plant spreads through the tree.



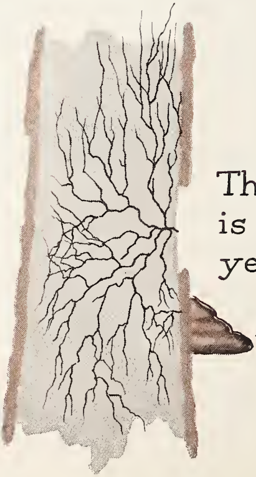
4

The plant sends out a shelf where spores grow.



5

The shelf grows bigger the second year.



6

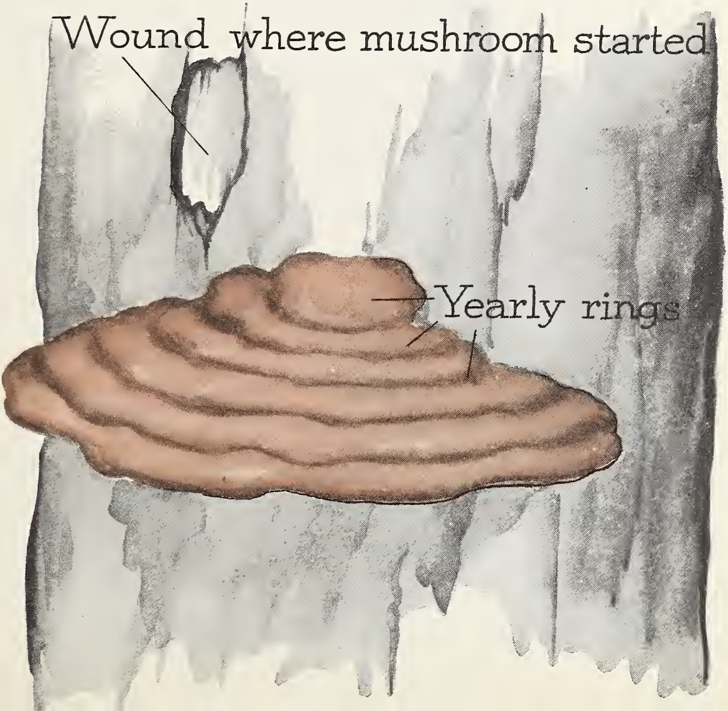
The shelf is three years old.

## Shelf Mushrooms

There are several kinds of shelf mushrooms. Some kinds live in dead trees. Some kinds are found in living trees.

Some of these plants make new shelves each year. Other kinds add new layers to the bottoms and the edges of the old shelves. You can tell the age of one of these shelves by counting the rings or by breaking it open and counting the layers.

It does not help a tree to break off a shelf. The main part of the mushroom plant is inside the wood. The shelf is somewhat like the fruit of a plant. The plant is not harmed when the shelf is broken off.

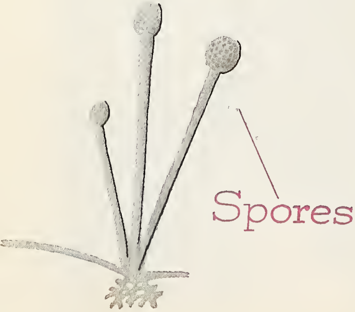


## Mould

Have you ever seen mould growing on food? On what kinds of food have you seen it growing?

Mould is another plant that cannot make its own food. It must use the food made by other plants. Bread mould uses starch in bread. What plant made the starch?

A mould plant is made up of tiny threads that cover the food it uses. At times little branches grow up from the threads. Knobs grow on the ends of the branches. The knobs are filled with spores.

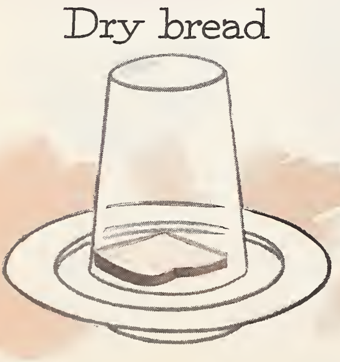


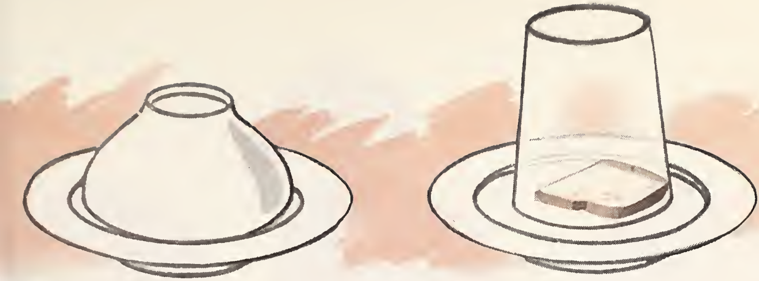
Mould gives off chemicals that flavour the food it grows on. Sometimes we do not like these flavours. We do not like the flavour bread mould gives bread. We do not like the flavours that moulds give jam and jelly.

We like some of the flavours that moulds give foods. We like the flavour that some kinds of moulds give cheese. Fresh cheese is like cottage cheese. This fresh cheese is mixed with certain kinds of mould, and then it is put away to "cure." While it cures, the mould grows and gives the cheese a special flavour. Each kind of cheese mould gives a different flavour.

You can raise bread mould on a slice of bread. Put half a slice of bread on a plate and leave it uncovered for ten minutes. Mould spores in the air will fall on the bread during that time. Then moisten the bread and cover it to keep the moisture from evaporating. Look at the bread a few days later.

Try some experiments to find out what makes bread mould grow best. Use a slice of dry bread in your first experiment. Leave the slice uncovered for ten minutes. Then break the bread in two parts and moisten one piece. Cover both pieces with drinking glasses and leave them for a few days. Does the mould grow better on the dry bread or on the moist bread?



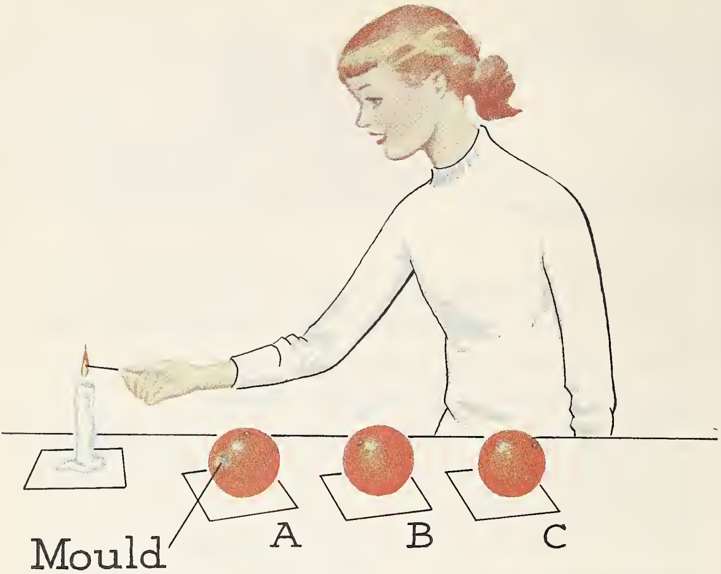


Find out if mould needs light to grow. Uncover a slice of bread for ten minutes. Put half the bread under a bowl and the other half under a drinking glass. In which place does the mould grow better?

Find out whether mould grows better in a warm place or a cold place. Perhaps you can keep the bread in a very hot place, also.

Mould plants are killed if they are heated to the boiling point. One way to keep fruit from spoiling is to bring it to a boil and put it in tight cans. Then mould spores cannot get to the fruit. What fruits are preserved this way?

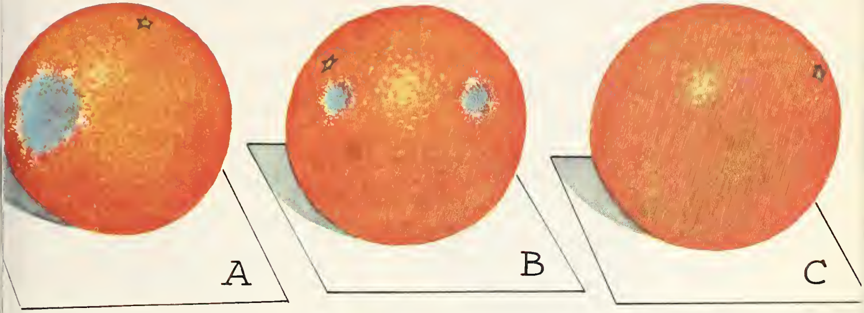
Mould plants cannot grow at temperatures below freezing. We can keep fruit from spoiling by keeping it frozen. What fruits are preserved this way?



Here is an experiment that will help you understand how bacteria are sometimes carried from one place to another. The experiment uses moulds instead of bacteria because you can see the mould without a microscope.

Find an orange that has some mould growing on it. Push a needle into the mould and then prick a good orange with the needle. Now hold the needle in a candle flame for a moment to kill any mould on it. Then prick another good orange with the needle.

Mark the oranges and look at them a few days later.



The spot of mould has grown bigger.

Spots of mould have started to grow.

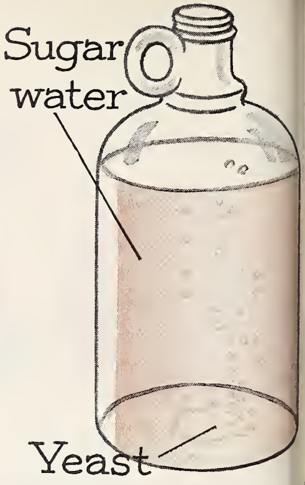
This orange is still good.

You will find mould growing on the first orange where you pricked it. The other orange will not have mould on it. Explain this.

Harmful bacteria may get into a cut in your skin the same way. The things that cut you are not usually clean. You can kill the bacteria in small cuts by putting in chemicals called antiseptics. This should be done before the bacteria begin to grow.

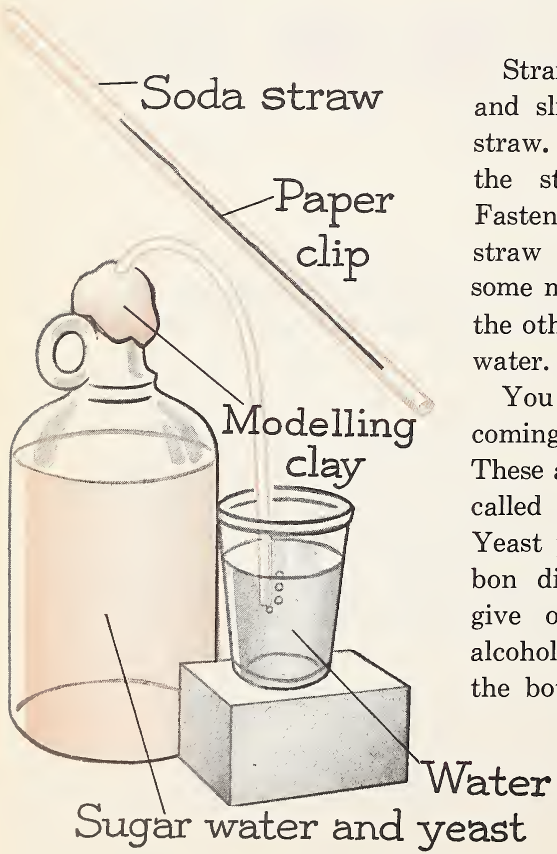
If possible, ask a doctor or a nurse to tell you how to treat cuts to keep bacteria from growing in them.

## Yeast



Put half a cup of sugar into a half gallon bottle that is nearly full of water. Mix a yeast cake in a little water and put some of it in the bottle too.

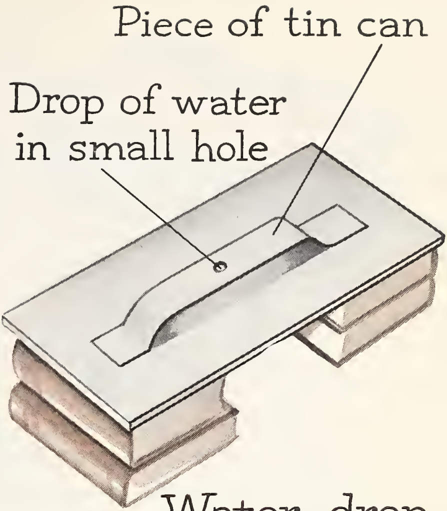
In a few hours you will see little bubbles rising from the water. There will also be a strange odour in the bottle.



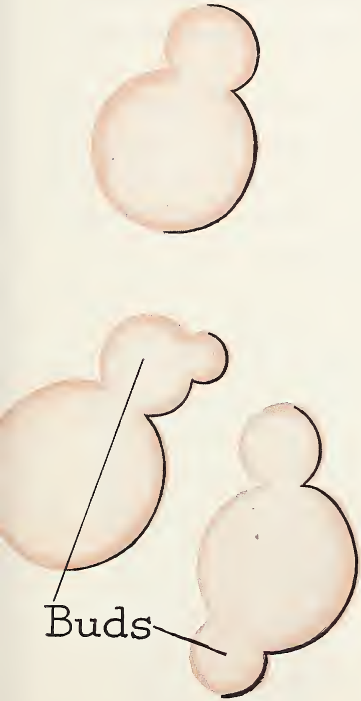
Straighten a paper clip and slip it inside a soda straw. You can now bend the straw in a curve. Fasten one end of the straw in the bottle with some modelling clay. Put the other end in a glass of water.

You will see bubbles coming from the straw. These are bubbles of a gas called **carbon dioxide.** Yeast plants give off carbon dioxide. They also give off alcohol. It is alcohol that you smell in the bottle.

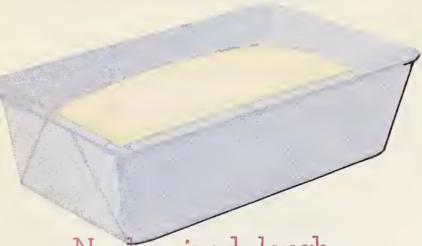
Put a drop of the yeast mixture under a microscope. A toy microscope or a water-drop microscope will show you the little yeast plants. They look somewhat like the ones in the picture.



Water-drop microscope



Do any of the yeast plants have knobs growing on them? These knobs are called "buds." The buds grow rapidly if the yeast has plenty of food. The buds soon break off and become more yeast plants.



Newly mixed dough

Dough ready for baking

## Yeast and Bread Making

Have you ever seen bread being made? The dough does not fill the pan at first. After it has been kept in a warm place for a few hours it swells up and fills the pan. Then it is baked.

Yeast is used to make the bread rise. You can try an experiment to show that yeast is needed to make it rise.

Find out from a cookbook how to make bread dough. Make some dough without any yeast in it. Make some more dough with yeast in it. Put some of both kinds of dough in glass dishes and set them in a warm place. Watch them and see what happens.

Dough with yeast

Dough without yeast

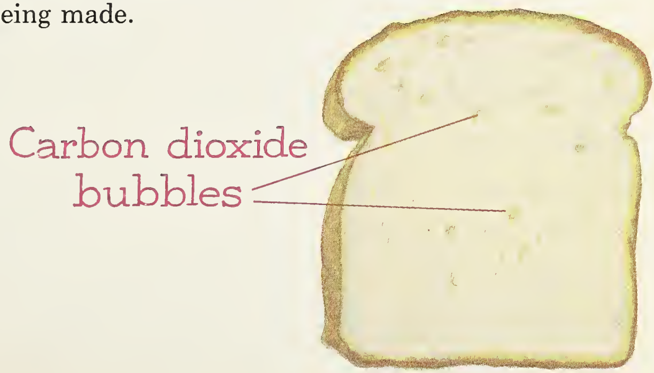
View of the rising room of a bakery

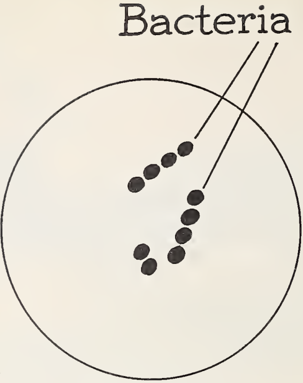
The yeast in the dough changes some of the starch into sugar. Then it uses the sugar for food. The yeast plants multiply very fast in the warm dough. Soon they give off bubbles of carbon dioxide.

These bubbles make the dough rise. When the dough is baked, the yeast is killed and the dough is cooked. The bread does not rise any more.

Look at a slice of bread. Notice the bubbles that were made by the carbon dioxide.

Try to visit a bakery to see bread being made.





## Bacteria

Bacteria are plants that are much smaller than yeasts and moulds. You can see them only with a microscope.

Bacteria cannot make their own food. They must take their food from other things. Many bacteria are useful such as those that make the soil rich. Some kinds are harmful such as those that give off poisons and make people sick.

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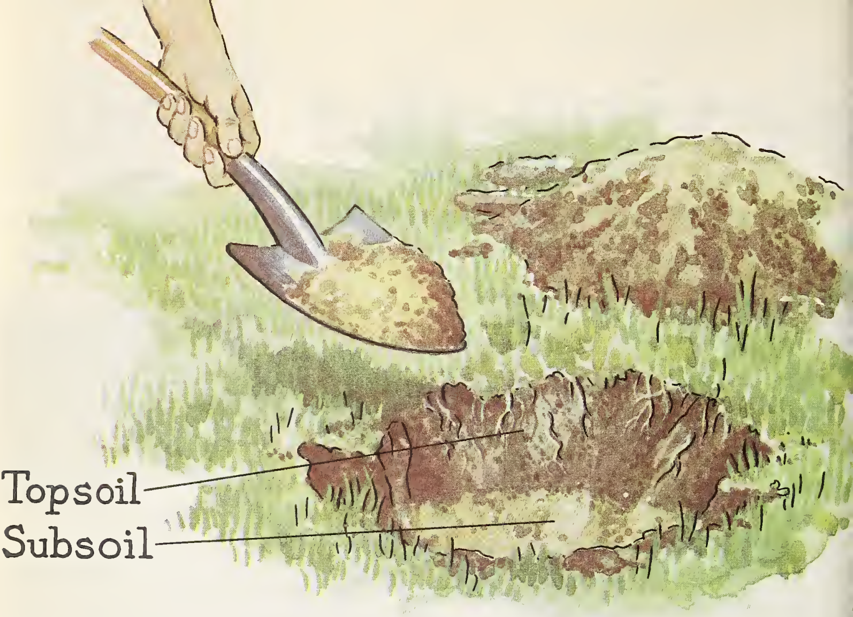
1. What can green plants do that other living things cannot do?
2. Where do mushrooms get their food?
3. What are the spores of mushrooms and moulds?
4. Why is yeast put in bread?
5. How do yeast plants multiply?
6. What are some foods that are spoiled by mould and what are some foods that are made better?
7. Why does wood in damp places decay?

# Saving the Soil



## Topsoil and Subsoil

Dig into the soil of a field or a garden. If you cannot do this, visit a cellar or a roadway that has just been dug out.

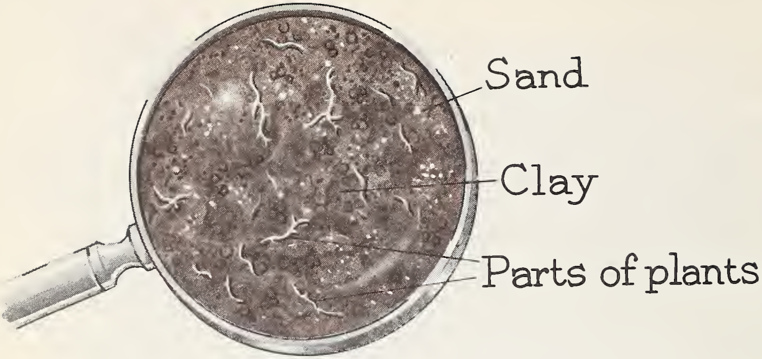
You will see that the soil changes colour a little below the top of the ground. The soil near the top is darker than the soil deeper down. The deeper soil is often yellow or red.

The upper soil is called **topsoil.** The lower soil is called **subsoil.** Usually the topsoil is less than two feet thick, although there are places where it is much thicker.

During heavy rains, streams of water may run down fields on steep hillsides. The streams pick up the topsoil and carry it away. Afterwards you may see gullies in the topsoil where the water has been flowing. Always it is the topsoil that is lost first.

We believe that we have lost a great deal of topsoil in this country since the forests were cut and the fields were first ploughed. Some of it washed away. Some of it blew away.

It is said that a third of our topsoil is gone. There are a few places where little topsoil has been lost, but there are many places where it is all gone.



## What Is the Topsoil Like?

Look at some topsoil and some subsoil with a hand lens. What are some of the differences?

Topsoil has bits of dead plants in it. These bits of plants decay and become a dark material called **humus.** Humus gives topsoil its dark colour.

Topsoil also has many living things in it. There are small animals. There are roots of plants. There are great numbers of tiny plants that are not green.

Earthworm

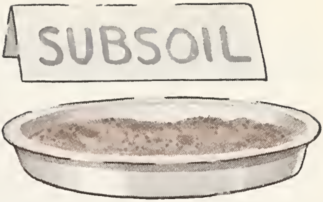
Millipede

Ant

Centipede

Sow bug

Beetle gr

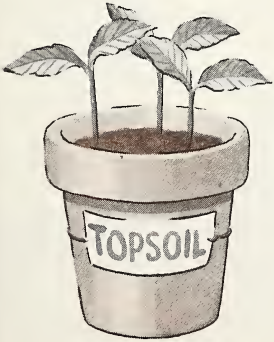


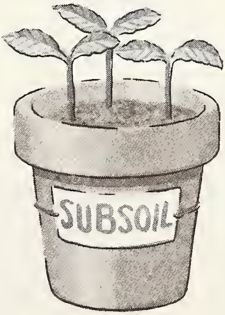
Plants usually grow best in loose soil. Their roots can push through it easily. They do not grow well in hard packed soil.

Break up some chunks of topsoil and subsoil with your fingers. Which chunks break apart more easily? Squeeze some wet topsoil and subsoil into balls and let them dry. Which break apart more easily?

Put some topsoil in one pan and some subsoil in another pan. Pour water into each until the water stands above the soil. Mix the water and soil and let them stand until they are dry. Which soil is harder when it dries? Which soil has more cracks in it?

These experiments show some of the reasons why topsoil is better for plants. Try planting seeds in both kinds of soil. Which plants grow better?





## Plants and Topsoil

Most plants grow well in topsoil. Topsoil is loose and the roots of plants push through it easily. Rain soaks into topsoil quickly. Topsoil usually has the minerals that plants need for good growth.

Topsoil is good for all kinds of cultivated crops. It is good for pastures. Good farms have thick topsoil.

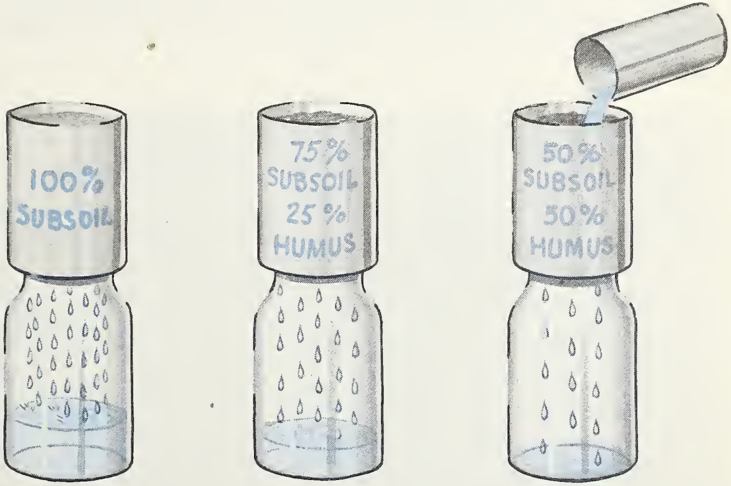
If the topsoil is lost, most plants do not grow well. The subsoil is hard and it packs harder during every rain. The rain cannot soak in quickly. It either runs off or makes puddles on the soil.

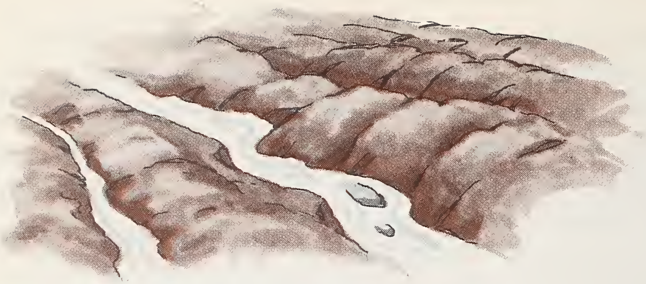
Such land is almost worthless for cultivated crops and pastures. It becomes poorer every year unless something is done to make it into better soil.

Plants slowly change subsoil into topsoil if they are not disturbed. Their roots push into the subsoil, where they die and decay to form humus. Plants that are carried down into animal holes also change into humus. Humus from the top of the soil is washed down into holes in the subsoil.

Humus changes subsoil greatly. Get some humus from a woodland or buy some in a garden store. Add a little humus to some subsoil. How does the humus change the colour of the subsoil? How does it change the way the subsoil packs together?

Punch holes in the bottoms of some metal cans and fill the cans with different mixtures of subsoil and humus. Pour equal amounts of water in each can and catch the water that runs through. How does humus change the amount of water that the soil soaks up?

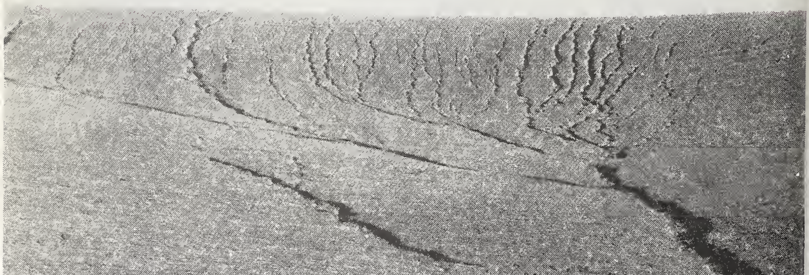




## Running Water and Topsoil

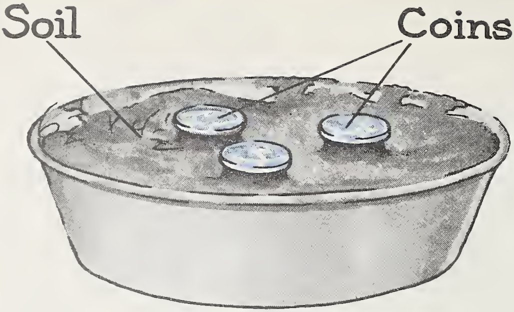
Running water carries away much of our topsoil. Whenever you see a muddy stream you are seeing valuable soil being carried away.

Bare hillsides lose topsoil very rapidly. During every rain, little streams of water begin to flow down the slopes. These little streams run together and make bigger streams. As the water rushes along, it picks up topsoil and carries it away. After one hard rain, a field may look like the one in the picture on this page.



Small gullies may not seem very bad. They are levelled off the next time the field is ploughed. But we must never forget that valuable topsoil has been lost every time we see a gully, no matter how small.

After several rains, gullies may be so big that they cannot be ploughed over. Then the field becomes useless. Unless something is done, the gullies grow deeper and longer. They may ruin other fields.



## Sheet Erosion

Fill a pan to the top with soil. Put two or three coins or flat stones on the soil. Set the pan outdoors on a rainy day. What happens?

If there is nothing to break the force of the raindrops, the soil is splashed about and mixed with water. As the water flows away, it takes some of the soil with it. A bare field loses some of its soil this way during every rain. This loss is called **sheet erosion.**

You can see signs of sheet erosion after heavy rains. Look for mud splashed on stones or plants. Look for stones held up by bits of soil while the soil around them has been washed away.

Not many people notice sheet erosion. There are no big gullies and there are no piles of mud at the bottom of a slope. Only a little soil is moved during one rain. Erosion is slow.

But year after year, sheet erosion goes on. A field loses more topsoil than it gets back. In time, so much topsoil has been lost that the field becomes worthless.

This picture shows a field that has lost nearly all its topsoil by sheet erosion. Perhaps you can find a field like this. Many farms have been made worthless by sheet erosion.

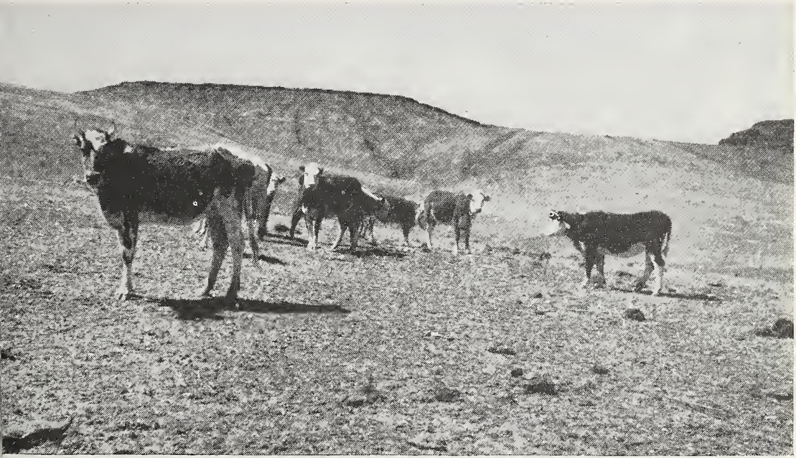
## Destroying the Soil Cover

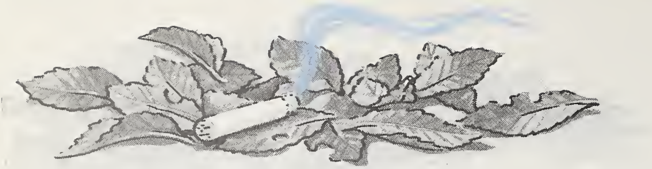
Plants are the best protectors of the topsoil. When we kill plants we increase the loss of our topsoil.

Of course, we must kill plants when we want to raise a crop. We must plough the wild plants under and leave the field bare for a time. However, it is safer to plough some fields than others. Steep hillsides should not be ploughed. Why is it safe to plough level fields?

People often kill plants by being careless or thoughtless. Some people start grass fires without thinking that the fire kills many of the plants and burns up much of the humus in the soil. Grass fires increase the loss of topsoil.

People often make the mistake of keeping too many sheep or cattle in one field. The animals eat the plants off close to the ground trying to find enough to eat. Soon the plants die and the topsoil begins to wash away. This picture shows a field which has become worthless, and these cattle can not be kept here.

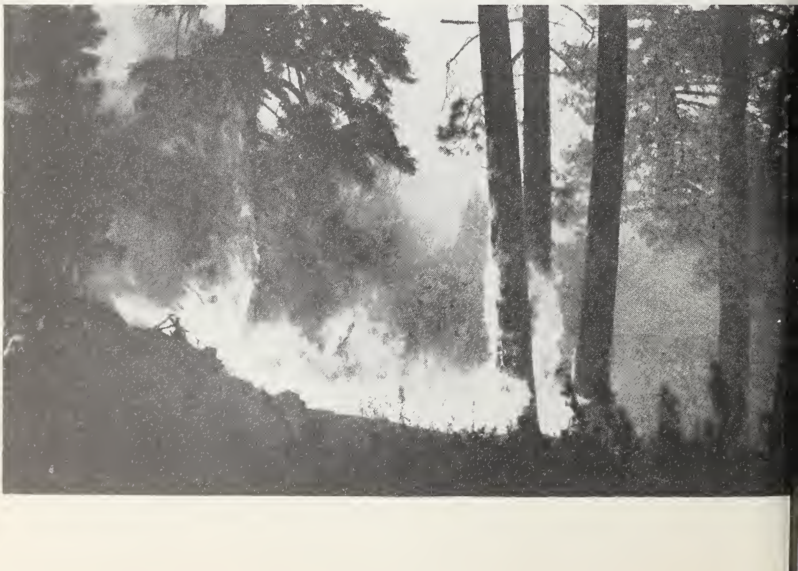


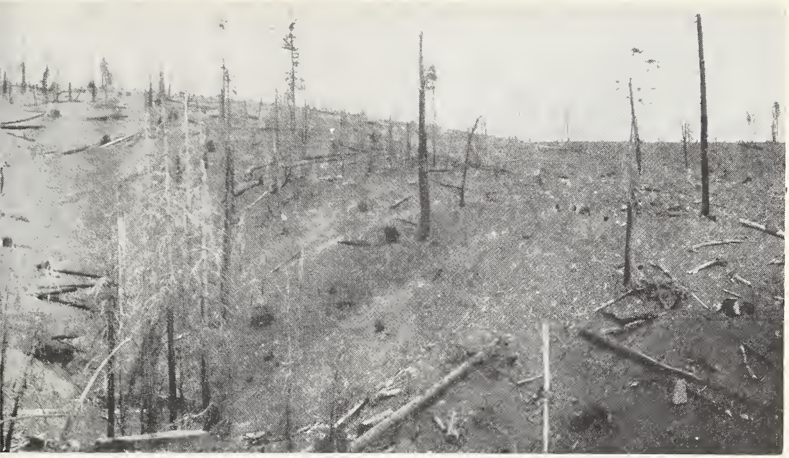


## Forest Fires and Topsoil

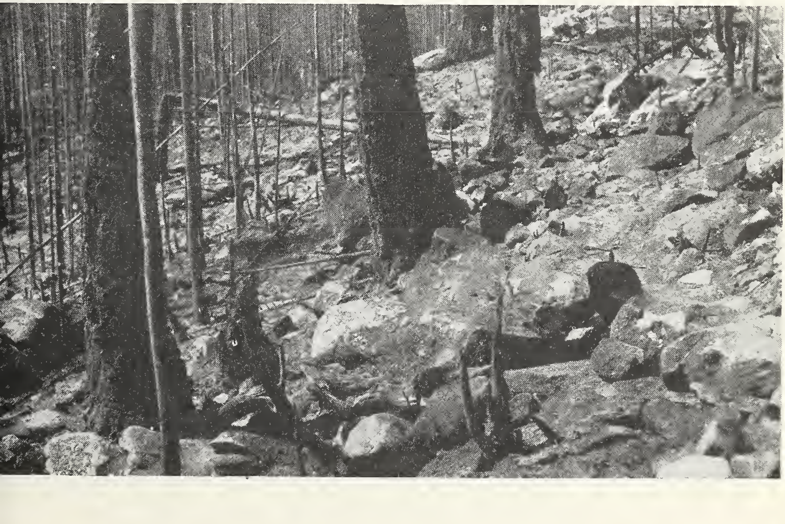
Forest fires not only destroy many trees each year, but they also cause the loss of much topsoil. Trees are good cover for the soil. Their roots hold it tightly. The leaves and twigs that they drop help stop sheet erosion. Humus comes from the leaves and other parts of the trees as they decay.

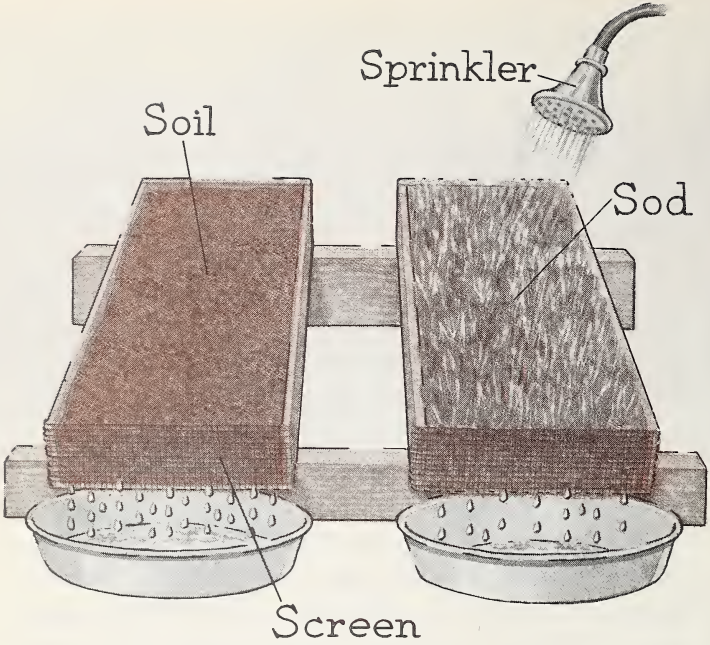
The picture shows us what happens in a forest fire. The leaves and twigs are burning. Small trees are being killed. The humus in the top layer of soil is being destroyed.





A hillside may look like this after a forest fire. There is nothing to hold the soil. Rain is already beginning to wash the soil away. The hillside may come to look like the picture below before new plants can grow and protect the soil.





## Giving Soil a New Cover

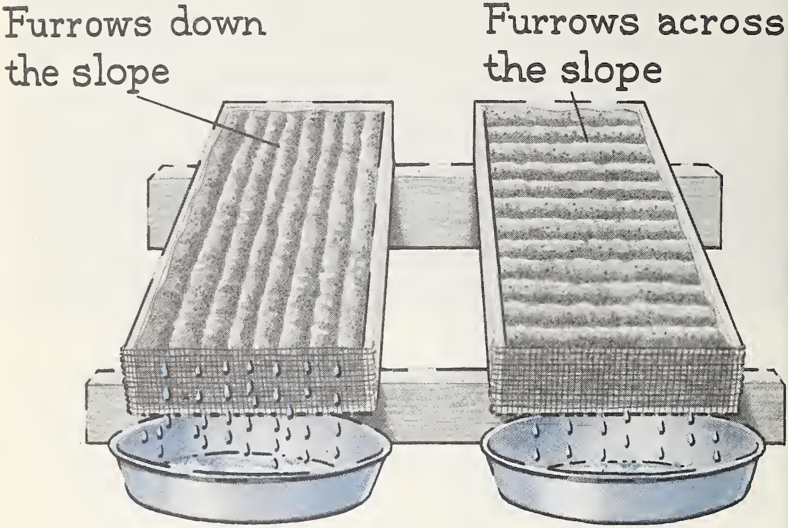
Make two trays like the ones shown above. The trays should be about three feet long. One end of each tray is closed with a board, and the other end has a piece of metal screening tacked across it.

Fill one tray with fine soil. Fill the other with fine soil covered by sod. Put blocks under the trays so they will slope.

Sprinkle each tray with the same amount of water. Catch the water that comes from the low end of each tray. Which tray loses more water? Which tray loses more soil?

The picture above shows poor soil. Only a little grass and a few weeds are growing there. These plants help hold the soil, but there are many open places where there can be sheet erosion. If the slope were steep enough, gullies might start in this field.

We can give this field a good cover of plants by fertilizing and seeding it with clover and grasses. The field will then become a good pasture instead of a worthless piece of land.

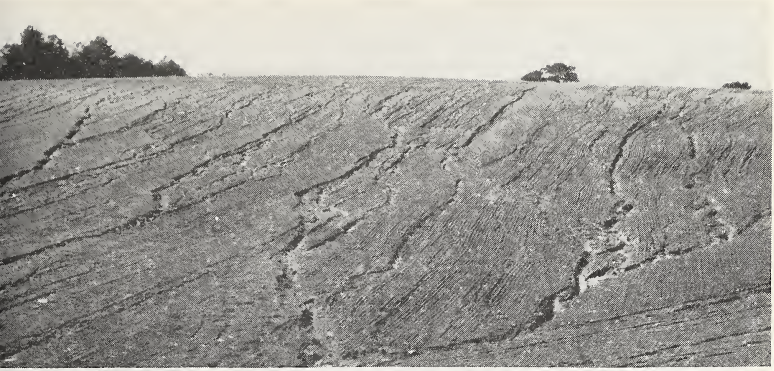


## Contour Ploughing

We must plough fields in order to have cultivated crops. We should learn to plough fields carefully so that not much soil is lost.

Use the same trays that you used in the last experiment. Fill each tray with fine soil. Put a block under each tray so that the slope of each is the same. Use a stick to make furrows up and down the slope in one tray and across the slope in the other tray. Sprinkle each tray with the same amount of water and catch the water that drips out.

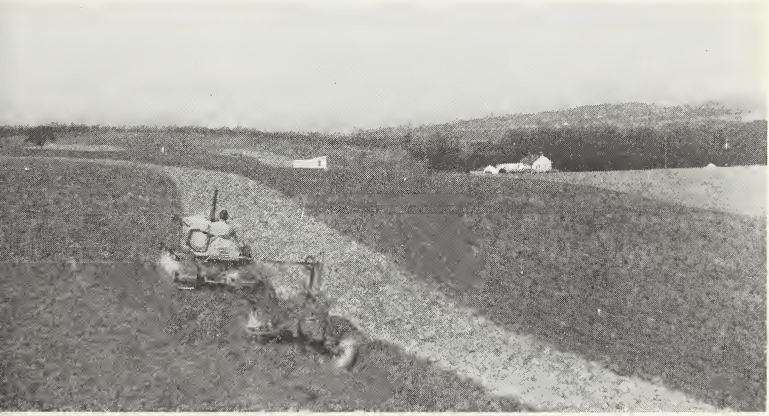
Which tray loses more water? Which tray loses more soil? Explain why.

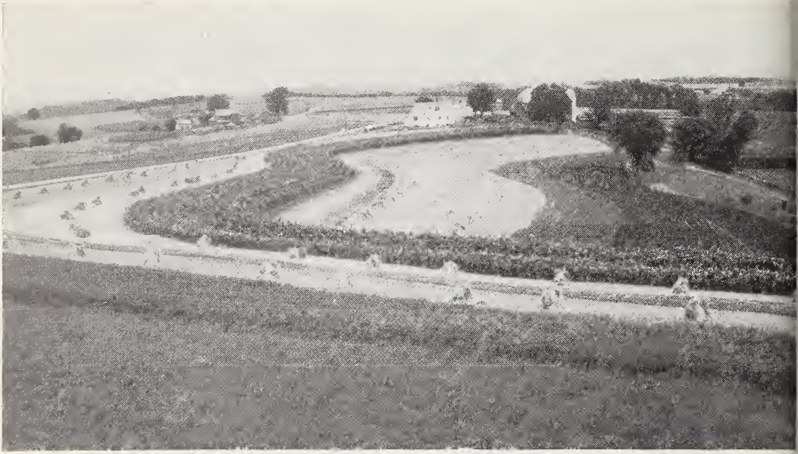


In the picture above we see a field that has been ploughed up and down the slope. See how rain has made gullies in it. Explain why.

Below we see a farmer ploughing along the slope. His furrows are level. His furrows curve where the hill curves. This is called **contour ploughing** because the furrows follow a level line around the hill.

Why is contour ploughing helpful in saving the soil? Why will soil be lost even with contour ploughing?





## Strip Cropping and Crop Rotation

Even with careful ploughing, gullies may start in a large, sloping field during a heavy rain. Little streams join together and make streams big enough to dig deep gullies.

Wise farmers use **strip cropping** with their contour ploughing. They raise different crops in strips along the slopes. The picture shows strip cropping on a hillside.

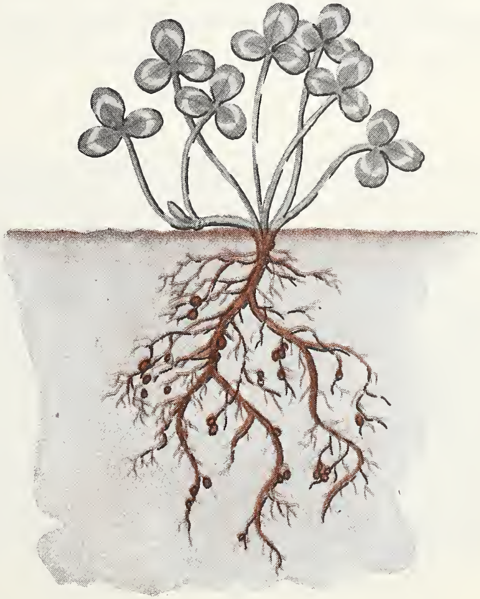
There is a pasture at the bottom of the hill at the right side of the picture. Above that there is a strip of potatoes. Then comes a strip of grass that will be cut for hay. Above that are strips of winter wheat, corn, and more winter wheat. At the top there is grass for hay.

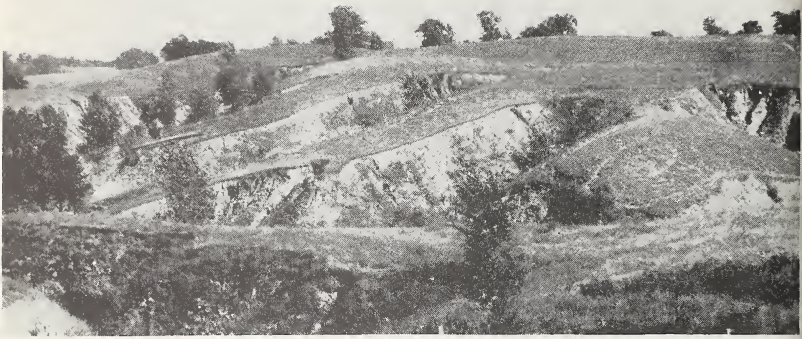
If a gully starts in one strip, the plants in the next strip stop it before it becomes very big. Soil may wash down the slope a short way, but it is soon stopped.

It is not wise to plant the same crop in a field year after year. Each kind of crop needs certain minerals from the soil, and it will quickly use up the minerals if nothing else is planted. The humus in the soil disappears, too, if nothing is done to put some humus back into the soil.

A wise farmer changes his crops around each year. He may plant potatoes this year where he planted wheat last year. He may plant corn next year where he grew hay this year. He will also plant things that can be ploughed under to make humus.

It is helpful to plant clover or one of its relatives every few years. There are useful bacteria that live on the roots of the clover family. These bacteria can take gases from the air and change them into materials that plants need for good growth.

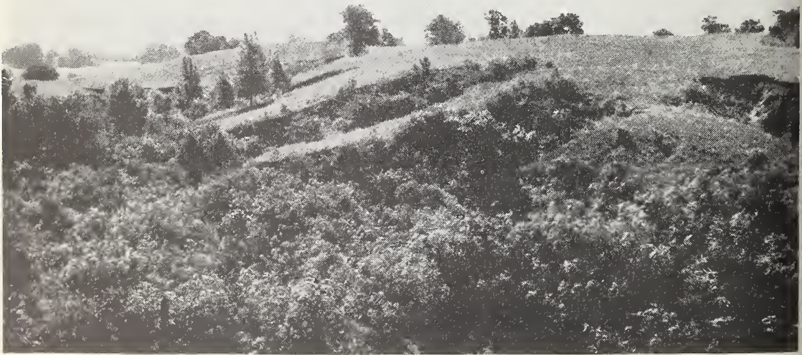


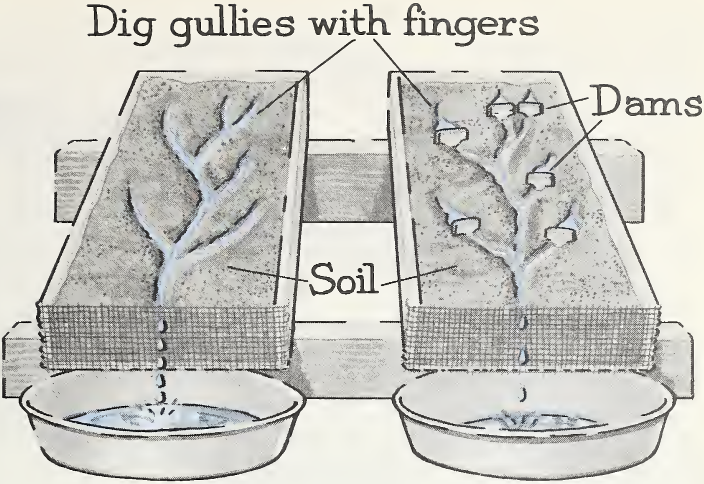


## Ways of Stopping Gullies

Gullies should be stopped before they grow long and ruin nearby fields. A field with many deep gullies in it may never again be good for cultivated crops.

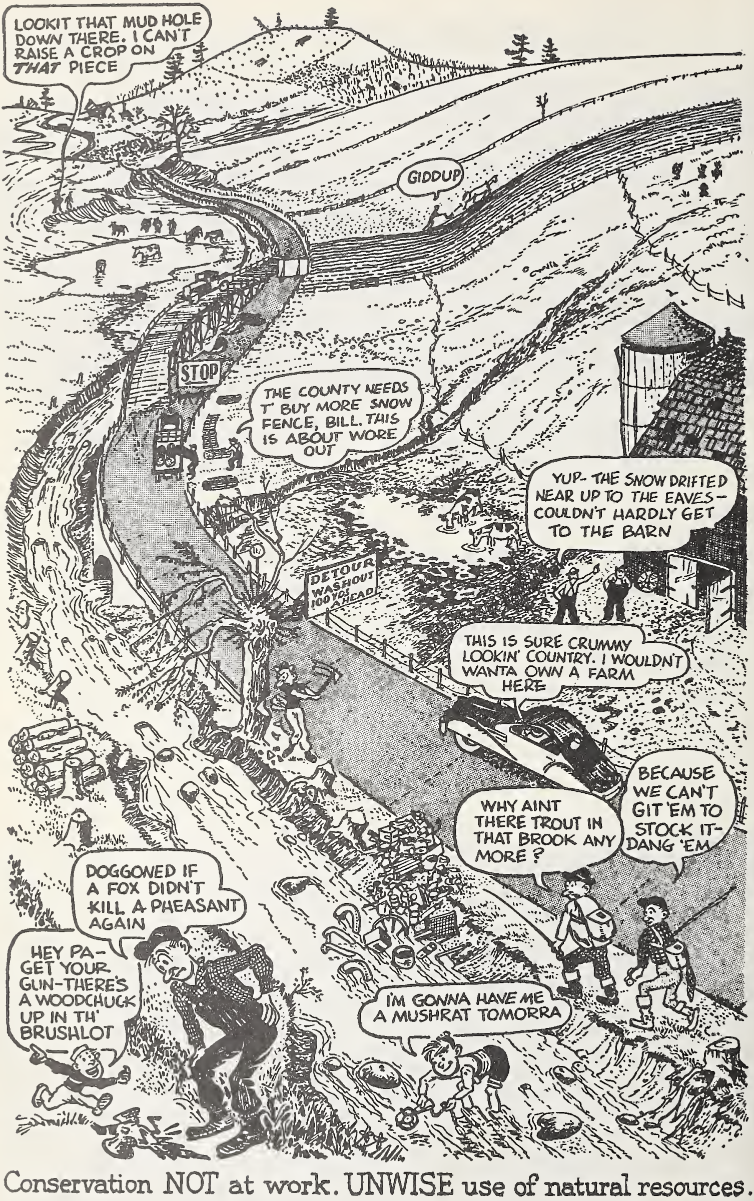
The gullies in the upper picture were kept from growing longer by planting vines and other plants along the banks. Four years later the gullies looked like the picture below.



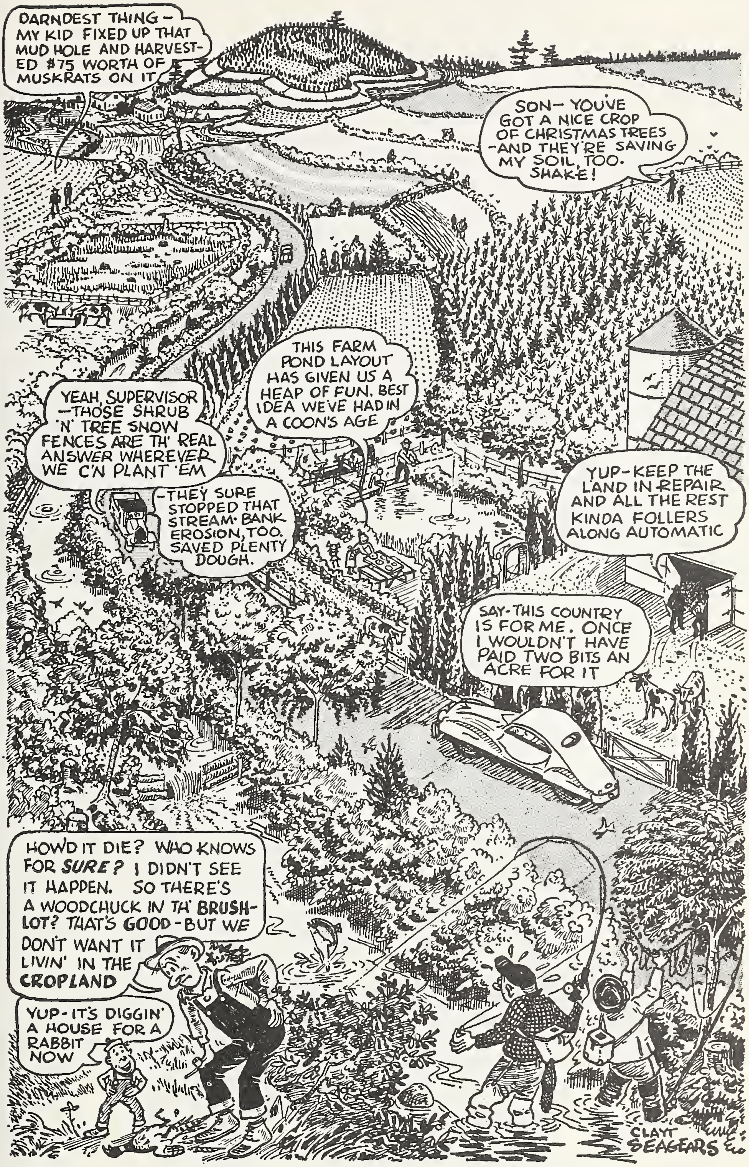


Sometimes gullies are too big to be stopped with trash and vines. Then dams should be built across the gullies. The dams slow down the water so that it does not dig into the soil so rapidly.

Set up an experiment to show how dams help slow down the water in gullies.


LOOKIT THAT MUD HOLE DOWN THERE. I CAN'T RAISE A CROP ON *THAT* PIECE
GIDDUP
STOP
THE COUNTY NEEDS T' BUY MORE SNOW FENCE, BILL. THIS IS ABOUT WORE OUT
YUP- THE SNOW DRIFTED NEAR UP TO THE EAVES- COULDN'T HARDLY GET TO THE BARN
DETOUR WASHOUT 100 YDS AHEAD
THIS IS SURE CRUMMY LOOKIN' COUNTRY. I WOULDN'T WANTA OWN A FARM HERE
WHY AINT THERE TROUT IN THAT BROOK ANY MORE?
BECAUSE WE CAN'T GIT 'EM TO STOCK IT- DANG 'EM
DOGGONED IF A FOX DIDN'T KILL A PHEASANT AGAIN
HEY PA- GET YOUR GUN-THERE'S A WOODCHUCK UP IN TH' BRUSHLOT
I'M GONNA HAVE ME A MUSHRAT TOMORRA

Conservation NOT at work. UNWISE use of natural resources.


DARNDEST THING - MY KID FIXED UP THAT MUD HOLE AND HARVESTED $75 WORTH OF MUSKRATS ON IT
SON - YOU'VE GOT A NICE CROP OF CHRISTMAS TREES - AND THEY'RE SAVING MY SOIL, TOO. SHAKE!
THIS FARM POND LAYOUT HAS GIVEN US A HEAP OF FUN. BEST IDEA WE'VE HAD IN A COON'S AGE
YEAH, SUPERVISOR - THOSE SHRUB 'N' TREE SNOW FENCES ARE TH' REAL ANSWER WHEREVER WE C'N PLANT 'EM
- THEY SURE STOPPED THAT STREAM-BANK EROSION, TOO. SAVED PLENTY DOUGH.
YUP - KEEP THE LAND IN REPAIR AND ALL THE REST KINDA FOLLERS ALONG AUTOMATIC
SAY - THIS COUNTRY IS FOR ME. ONCE I WOULDN'T HAVE PAID TWO BITS AN ACRE FOR IT
HOW'D IT DIE? WHO KNOWS FOR SURE? I DIDN'T SEE IT HAPPEN. SO THERE'S A WOODCHUCK IN TH' BRUSHLOT? THAT'S GOOD - BUT WE DON'T WANT IT LIVIN' IN THE CROPLAND
YUP - IT'S DIGGIN' A HOUSE FOR A RABBIT NOW
CLAYT SEAGEARS

Conservation AT work. WISE use of natural resources.

## Wind Erosion

This is a picture of a dust storm. Much topsoil can be lost in storms of this kind. The dust usually comes from bare fields. How can this loss be kept smaller?

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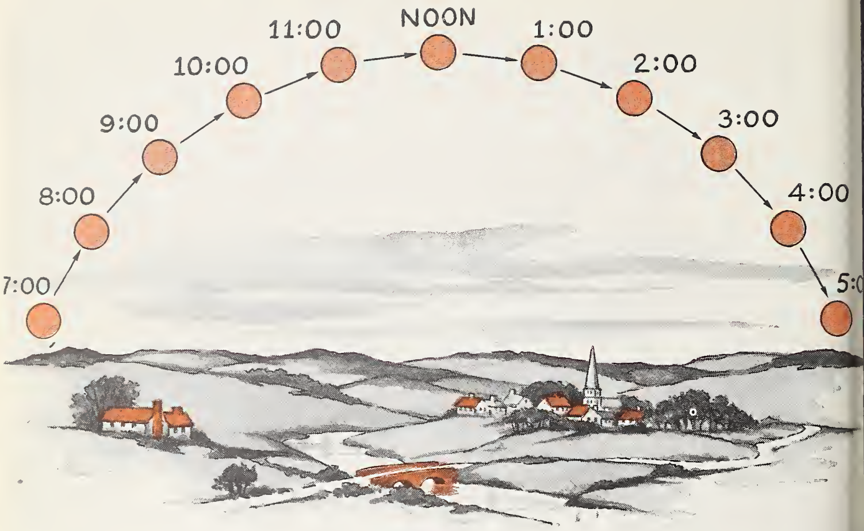
1. What is topsoil?
2. How does subsoil become topsoil?
3. What are some reasons why topsoil is lost?
4. How do grass fires and forest fires harm the soil?
5. What is contour ploughing and why is it used?
6. How can we keep topsoil on steep hillsides?
7. What can we do to keep gullies from becoming bigger?

# Time and Seasons

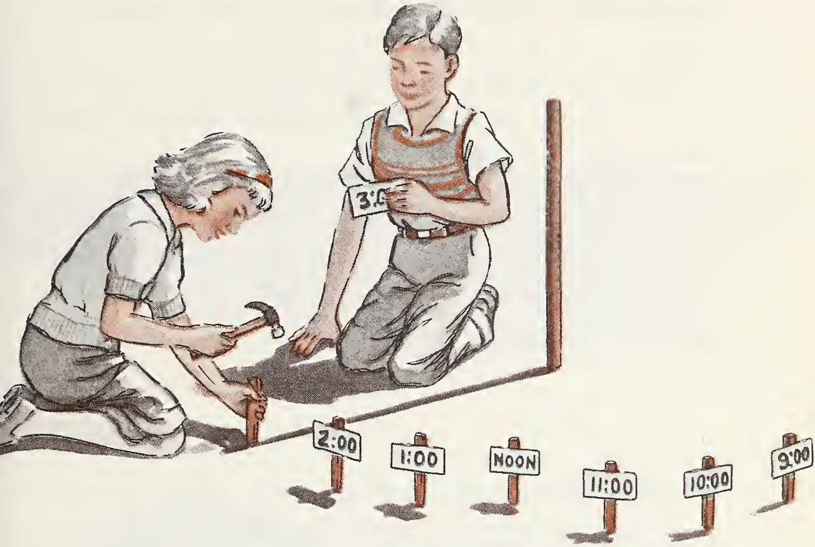


# The Sun and Its Shadows

Every day the sun seems to rise, move across the sky, and set again. It is so regular in its movements that it has always been a good timekeeper.

Today we have clocks to help us tell time, but we still use the sun also. We know the difference between morning and afternoon by the sun. We know when evening is near at hand. We know when it is nearly noon.

You will find the sun very useful as a timekeeper. Make a habit of noticing where it is at different times of day. Often you will be able to guess the time when you have no watch.



Drive a pole into the ground in a place that is sunny all day. Watch the shadow of the pole. How does it change as the sun moves?

Each hour drive a small stake into the ground at the end of the shadow of the pole. Mark each stake so that you can tell when you drove it into the ground. You can use the stakes to tell time for several days.

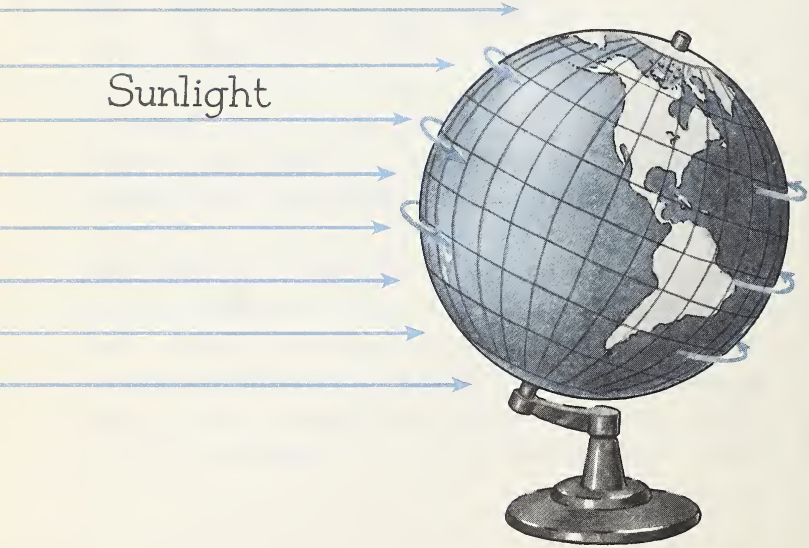
Use a compass to find the direction the shadows point. Find the shadow that points most nearly north.

## Days, Years, and Months

Until about 500 years ago, people believed that the sun travelled around the earth. They said that a day was the time needed for the sun to go once around the earth.

Today we believe that the earth is round and that it spins like a top. We also believe that the earth travels around the sun.

We say that a day is the time needed for the earth to turn around once. Put a globe in sunlight and turn it slowly. When the sun is south of the place where you live, it is noon. Turn the globe until it is noon again. One day has passed.



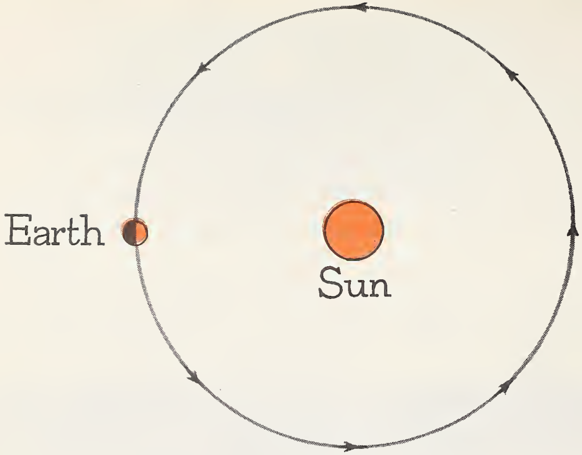
Let us suppose that the earth is really spinning as most people believe. Then the reason that the sun seems to move across the sky is because we ourselves are moving.

Go outdoors and look at the sky. Which way does the sun seem to move? Which way must the earth be spinning to make the sun seem to move as it does?

Look at the skyline in the west. Imagine that it is rising. What time of day will it be when the skyline seems to reach the sun?

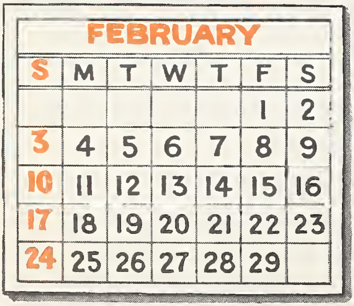
Look at the eastern skyline and imagine that it is moving. When does sunrise come?

Where will you be when midnight comes?



We believe that the earth has another motion too. We believe that it travels around the sun in a path that is almost a circle. The time needed for the earth to travel once around the sun is called a year.

The earth needs about 365¼ days to travel once around the sun. When we divide the year into days, there is a quarter of a day left over. We cannot put a quarter of a day on the calendar, so we add one full day every four years. In what month do we add the extra day? When will the extra day be added again?



FEBRUARY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
|  |  |  |  |  | 1 | 2 |
| 3 | 4 | 5 | 6 | 7 | 8 | 9 |
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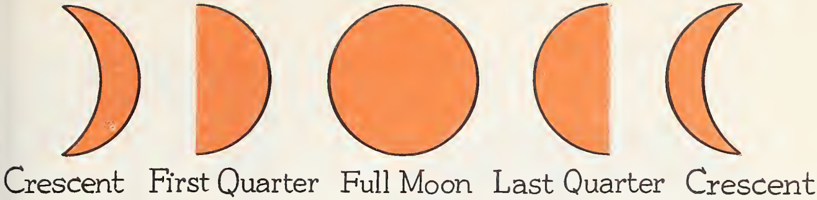
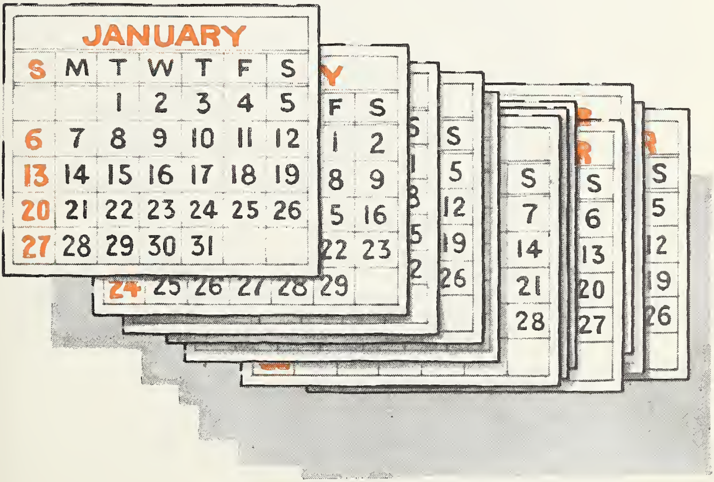


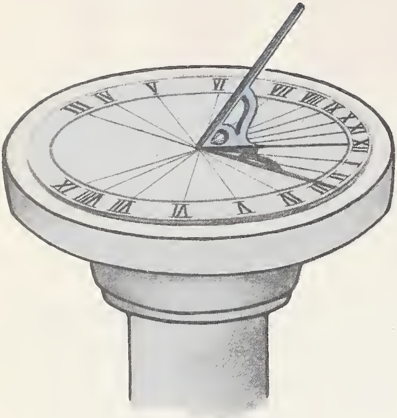
The word "month" comes from the same word that gives us the word "moon." A month has often been called a "moon."

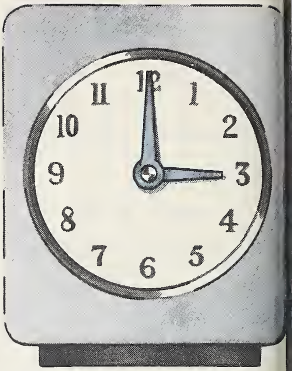
Watch the moon for a few weeks and you will see that it changes shape. At first it is a little sliver of light in the western sky. Night by night it grows larger until it is fully round. Then it grows smaller again until you can no longer see it.

The time needed for the moon to go through these changes is almost 30 days. There are twelve "moons" in a year with a few days left over. Count the days in each month to see how we take care of the extra days.



Sundial





Twelve-hour clock

## Clock Faces

When the sundial was invented, people decided to divide the time of daylight into twelve parts called hours. Later, they decided to divide the whole day into two parts of twelve hours each. That is why we now have clocks that show only twelve hours even though the day is twenty-four hours long.

How do we write time so that it tells whether it is before or after noon? Look at some timetables and find out how to tell whether a train or a bus leaves in the daytime or the nighttime.

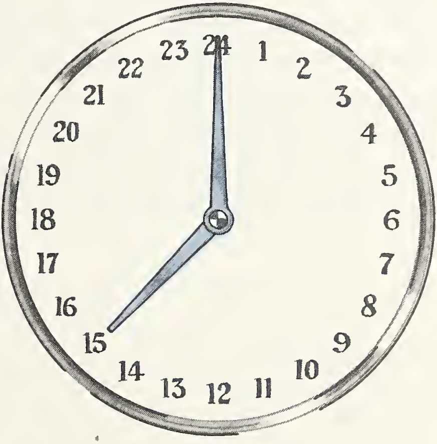
How many times in one day does the hour hand of the clock shown above go around? Does the clock tell you whether it is day or night? How do you know whether it is day or night?

The twelve-hour clock often causes trouble. A person may miss a train if he makes a mistake in reading a timetable. Sometimes a person writes down the time and forgets to write A.M. or P.M. after it, and then he does not know what the time really should be.

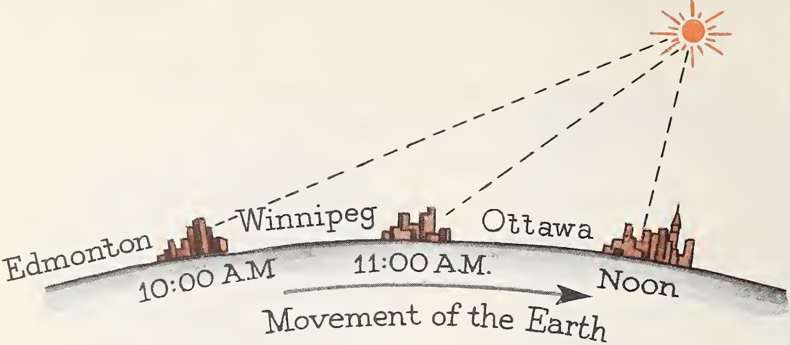
The twenty-four-hour clock is easier to use. The hour hand goes around once a day. 1200 hours is noon. 600 hours is the same as 6:00 A.M. 1800 hours is the same as 6:00 P.M. What time is 1500 hours?

The armed forces of some countries use the twenty-four-hour clock. How can a mistake between A.M. and P.M. be important to an army or navy?

Make a clock face with twenty-four hours on it. Fasten on hands that will turn around. Keep the hands set at the proper time.



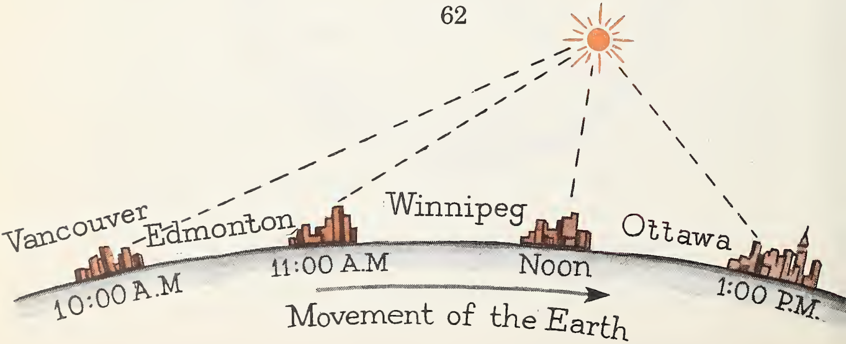
Twenty-four-hour clock

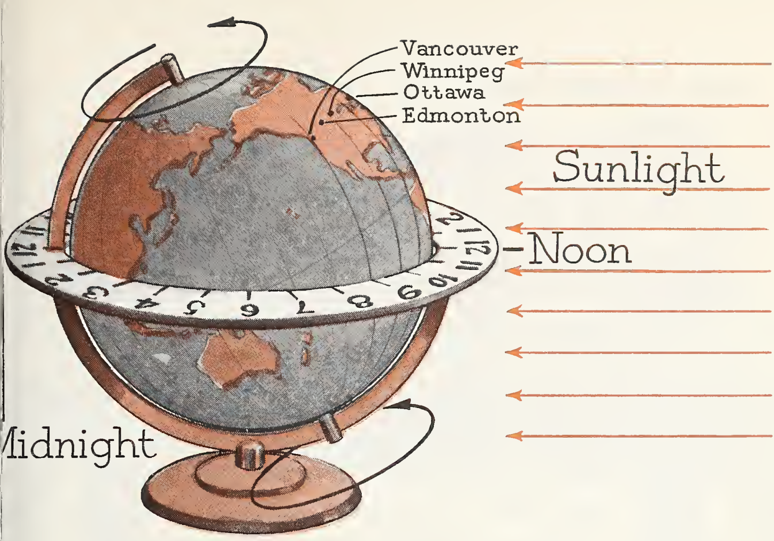


## Time Over the Earth

When using a radio or a television set, have you noticed that football games in one part of the country do not come at the same times as they would where you live? Many places in the country have a time different from your own. Listen to a radio or watch television, and keep a record of places that have different times.

The diagrams on this page show why we have different time in different places. The sun cannot be overhead everywhere at the same time, so noon must come earlier in some places than in others. When it is noon in Ottawa, people in Winnipeg must wait about an hour before noon comes. Look at these diagrams and explain the difference in time in the other cities.





This picture shows how time changes over the whole earth. Imagine that the earth is turning inside the ring. It is noon in Ottawa and the sun is overhead. What time is it in Vancouver? In Shanghai? In what part of the world is it midnight?

Set a globe in sunlight and turn it until it is like this picture. Where is the sunrise? Where is the sunset?

From the picture above, you can see that the earth must turn for three hours before it is noon in Vancouver. Turn the globe until it is noon in Vancouver. Where is the sunrise now? Where is the sunset? Where is it midnight? Can you figure out what time it is in Winnipeg?

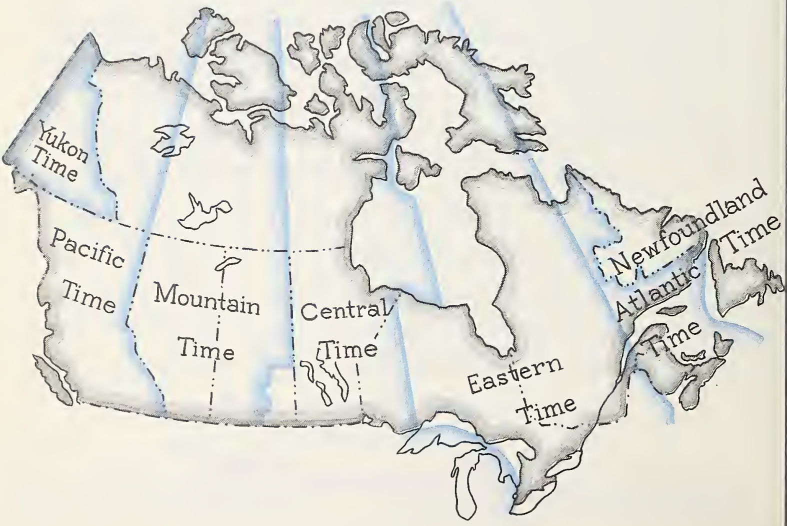
Turn the globe until it is midnight in Vancouver. How many hours would the earth have needed to turn half way around like this? Where is it noon?

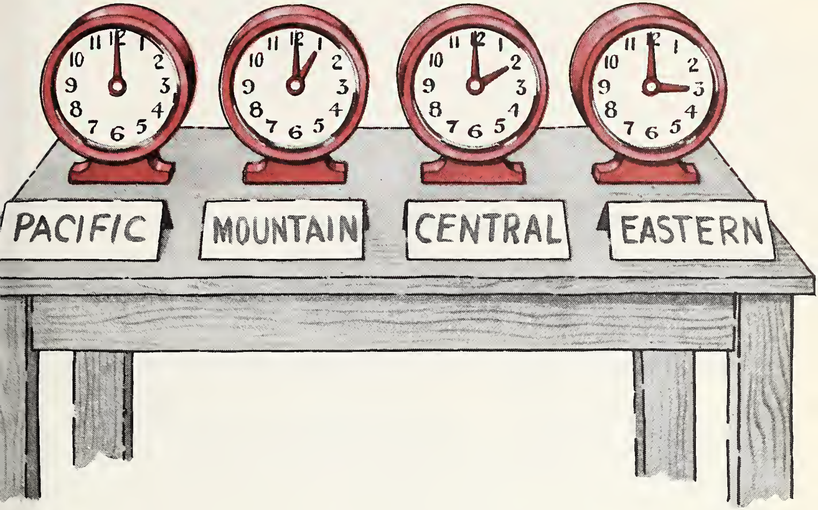
## Standard Time

Once every city had its own time. What would happen as you went from one place to another? What do you think a timetable would look like? Give some reasons why we would not like so many kinds of time today.

When railroads became common it was decided to have fewer kinds of time. The country was divided into seven time zones as are shown on the map below. The time is the same everywhere in each zone and is called standard time. Which time zone do you live in?

Study some train, bus, and airplane timetables. Pretend that you are taking a trip across the country. Where would you change your watch? How would you change it?

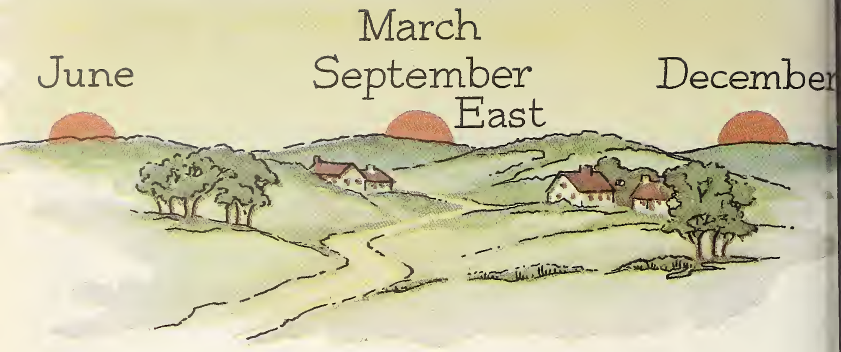




Bring several clocks to school and start them running. Set one clock to read the time in your own time zone. Set the other clocks to read the time in other time zones of the country.

Imagine what is going on in schools in other time zones. When you are eating lunch what are the other pupils doing? When you leave school, are other pupils still in school or did they go home earlier? When you are starting school what are the other pupils doing?

Some cities and towns move the clock ahead one hour during the summer months. This is called daylight-saving time.



## The Changing Path of the Sun

People sometimes say that the sun rises in the east and sets in the west. Let us see if this is always true.

Watch the sun rise in the morning and make a note of the place where you first saw it. A good way of keeping a record is by making a drawing like the one above. Keep a record of the time too.

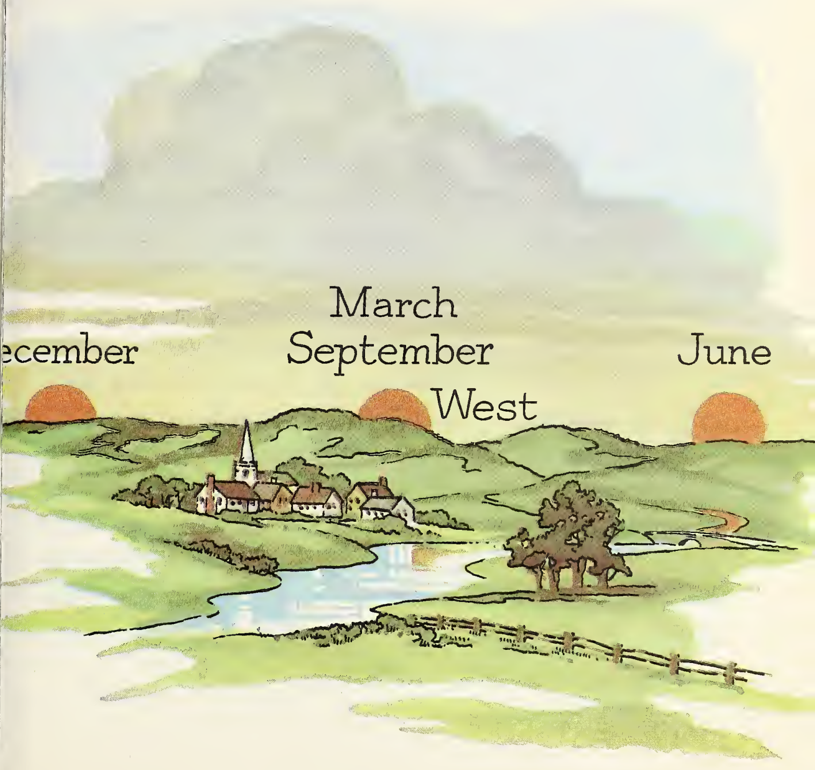
Use a compass to find out if the sun came up exactly in the east.

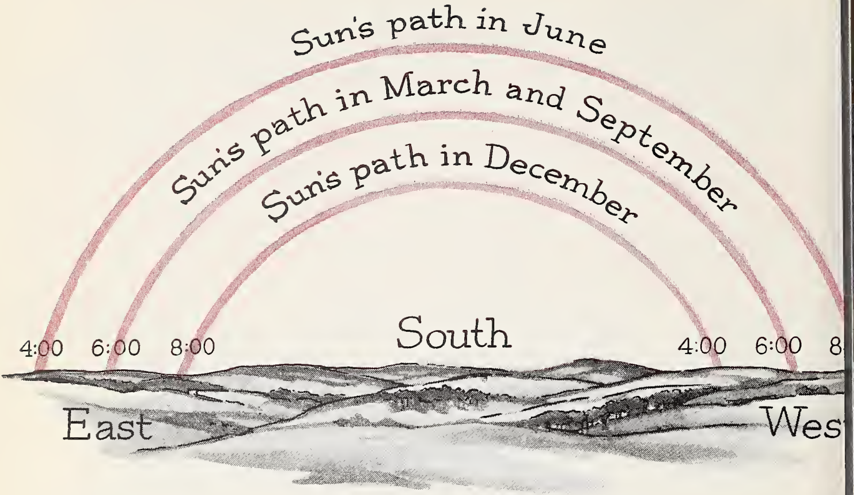
A few days later watch the sun come up again. Does it come up in the same place as it did before? Is it farther to the north or to the south? Did the time change?

Find out whether the sun sets in the west the same way. Find out whether the time of sunset changes. Make records of the time and place on a drawing of the western skyline.

If you like this kind of science work, keep a record of sunrise and sunset for several months.

An almanac gives the time of sunrise and sunset. Which day has the earliest sunrise? Which day has the latest sunset? Which day has the latest sunrise? Which day has the earliest sunset?

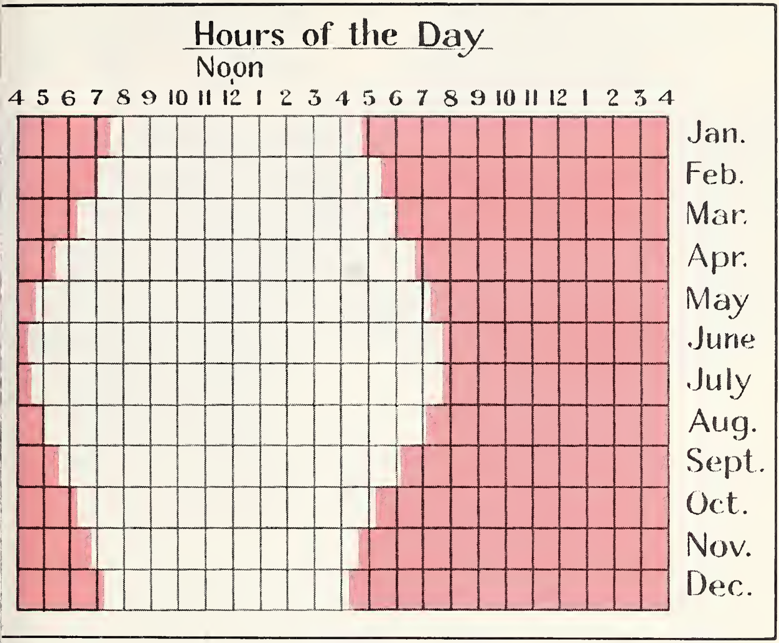




If we could watch the sun all day on certain days of the year, and then make drawings of its path, we would have something like the diagram above.

In December the sun rises about 8:00 A.M. and sets about 4:00 P.M. These times are not exactly the same in all parts of the country. In December the sun's path is a curve low in the southern sky.

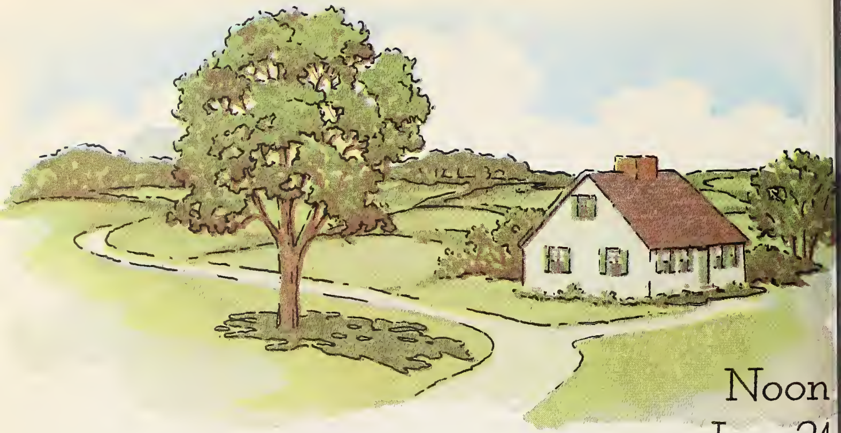
During the next few months, the days become longer and the sun's path becomes higher. In March there are a few days when the daylight hours and the night hours are about the same in length. What happens to the length of the daylight hours between March and June? What happens between June and December?



Above is a record of the hours of daylight and darkness in Toronto, Ontario. The record would be a little different for other cities.

Make a record like this for your own city or town. You can find the times of sunrise and sunset in an almanac.

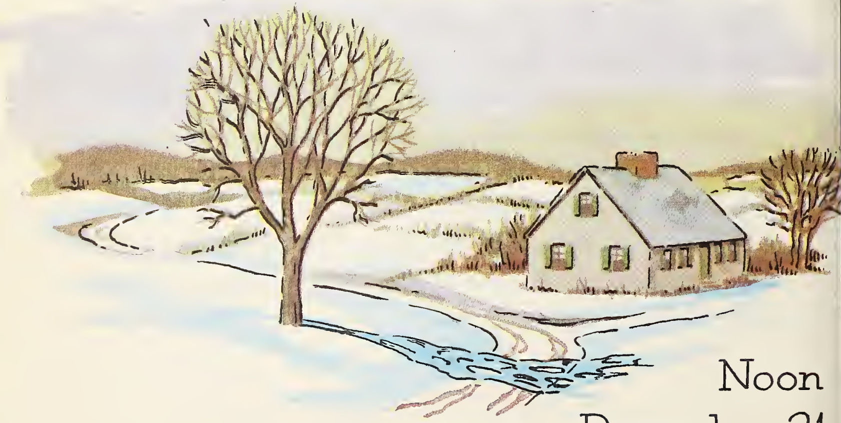
Count the hours of daylight in one day of each month. Which one has the most daylight? Which has the least daylight? Which days have nearly equal hours of daylight and darkness?



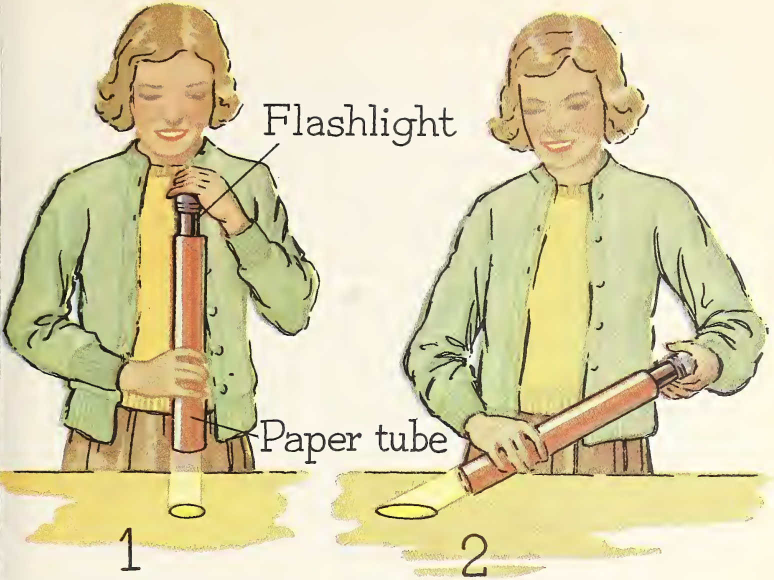
Noon
June 21

In late June the sun is almost overhead every noon. In December the sun is low in the southern sky at noon.

What do the shadows in these two pictures tell you about the position of the sun in the sky? Once a month make a picture record of the shadows around your school.



Noon
December 21



Make a roll of heavy paper to fit around a flashlight as shown in the pictures above. Darken the room as much as possible and turn on the flashlight.

First hold the tube straight up and down. Then slant the tube slowly. What happens to the spot of light? When is the spot brightest?

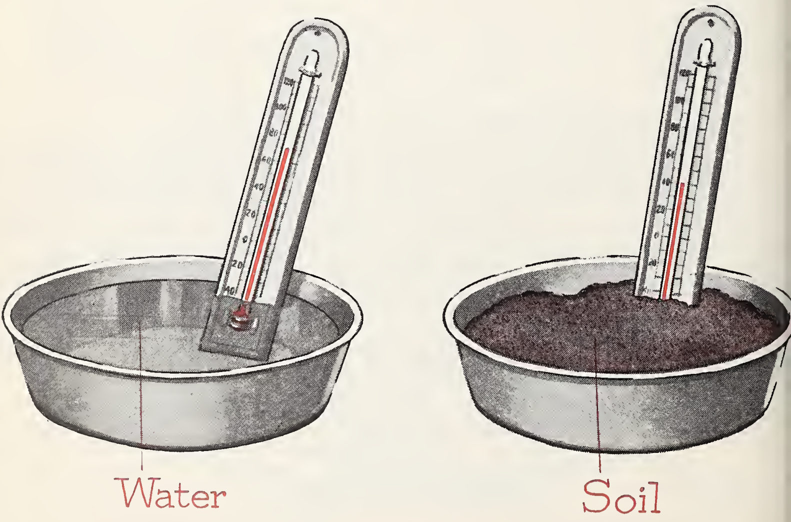
In summer at noon the sun shines almost straight down as the flashlight does in the first picture. In winter at noon the sun shines on a greater slant as the flashlight does in the second picture. Which is brighter, winter sunlight or summer sunlight?

## Seasons and Weather

You should now know about the two reasons why summers are warmer than winters. 1) Summer sunshine is warmer than winter sunshine. 2) The sun shines longer in summer than in winter.

In summer the soil, the water, and the air gain more heat than they lose. In winter they lose more heat than they gain. Put some dry soil in one pan and some water in another pan. Place a thermometer in each pan. Set the two pans in sunlight and read the temperatures every ten minutes. Now place the pans in shade and read the temperatures every ten minutes.

Do the temperatures of the soil and water change quickly or do they change slowly?

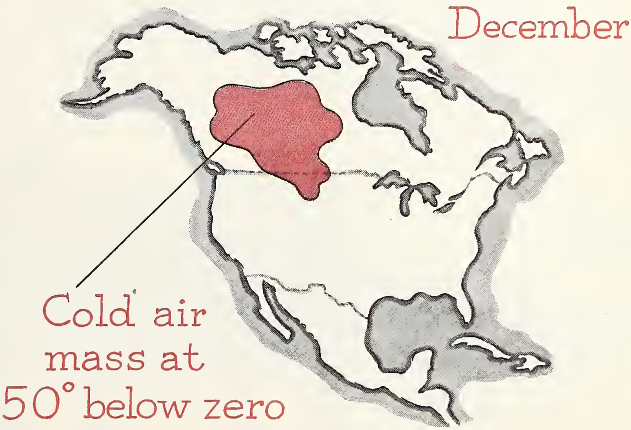


This experiment should help you understand several things about the weather. The sun is warmest at noon but the warmest part of the day is usually later in the afternoon. This is because the soil, water, and air heat up slowly. The coldest part of the day is often just before sunrise. This is because the soil, water, and air cool slowly.

Sunlight is warmest in late June. Why are July and August usually the warmest months?

Heating and cooling in one place may change the weather for people many miles away. During the winter in northern Canada, the air may cool to 50 degrees below zero. Masses of this cold air break away and move southward and eastward. They bring very cold weather with them. Watch some weather maps this winter to see how far some cold masses move.

There is warm air over the Gulf of Mexico, too. Masses of this warm air often move north and bring warm weather. Watch weather maps for these masses.

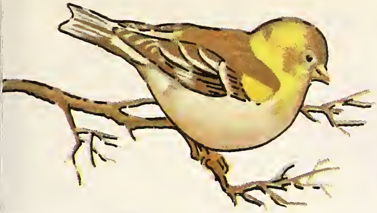


## The Seasons and Living Things

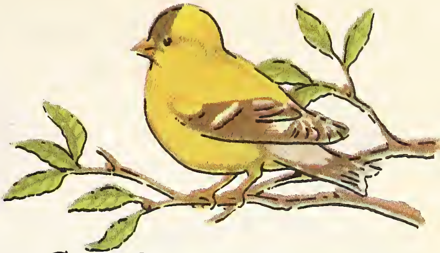
Many living things change as the seasons change. Some plants grow new leaves in spring and lose them in the fall. Name some plants that lose their leaves in the fall, and name some that do not lose them. Some plants, such as tulips, bloom only in the spring. Others, such as goldenrod, bloom only in late summer and fall. Some plants, such as petunias, bloom all summer. Name more plants of each kind.

Experiments show that a change in the amount of light changes the way some plants grow. Greenhouse workers have learned that some plants bloom only when the days are long. They make these plants bloom in winter by turning on electric lights for a few hours each evening. They have learned that other plants bloom only when the days are short. They make these plants bloom in summer by covering them with a dark cloth part of each day. Visit a greenhouse and ask about these plants.

Chrysanthemum
a short-day flower



Goldfinch in winter



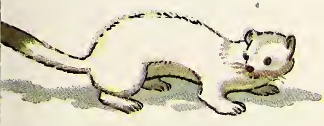
Goldfinch in summer

Insects, toads, snakes, and many other animals are more active in warm weather than in cold weather. Most of them crawl into hiding places in the fall and are quiet until warm weather comes again.

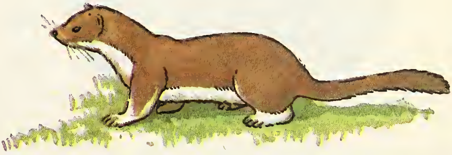
However, woodchucks begin their winter sleep in late summer and end it in late winter. It cannot be temperature that makes them do this. We do not know the real cause.

Many birds also fly south in late summer while the weather is still warm. Some experiments make us think that the change in the length of day sends them south, but we do not know for sure.

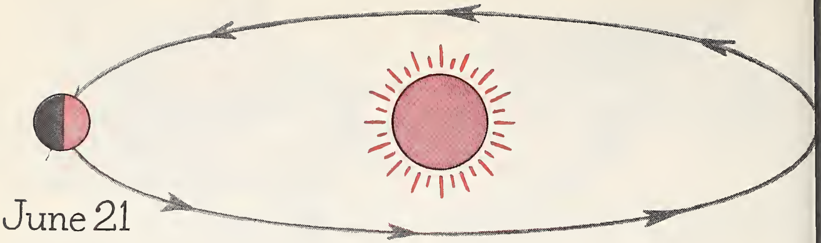
It is also interesting to study the way animals change their coats as the seasons change. Most birds and fur-bearing animals lose their old coats in late summer. Some of them also gain new coats in early spring as well. We do not know what makes them do this. There is much for us to learn about animals.



Weasel in winter



Weasel in summer

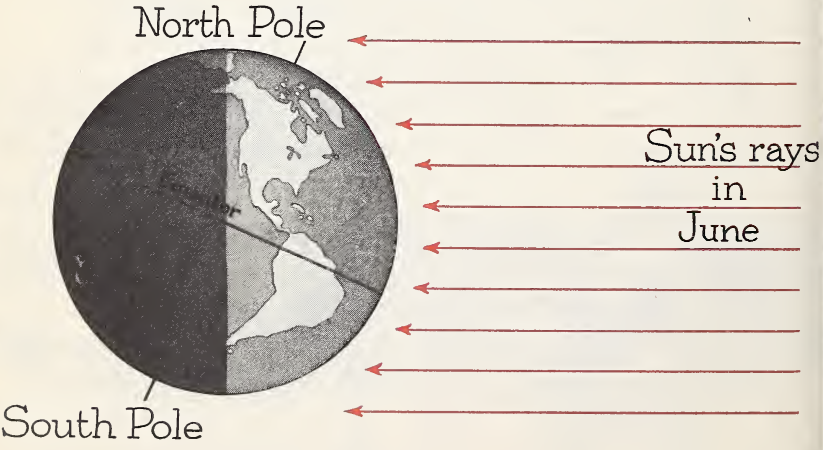


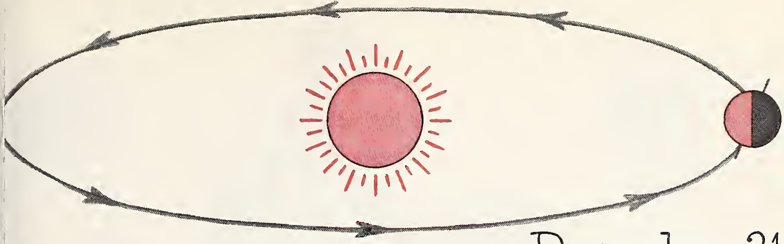
## Why Seasons Change

We have seen that long daylight hours and a sun high in the sky bring warmer weather. Let us now see why the sun's path changes.

We believe that the earth goes around the sun along a path that is almost a circle. We also believe that the earth is tipped a little as shown in the pictures on this page.

In June the northern half is tipped toward the sun. This part of the earth has more sunlight in June than at other times of the year. The land, the water, and the air become warm.

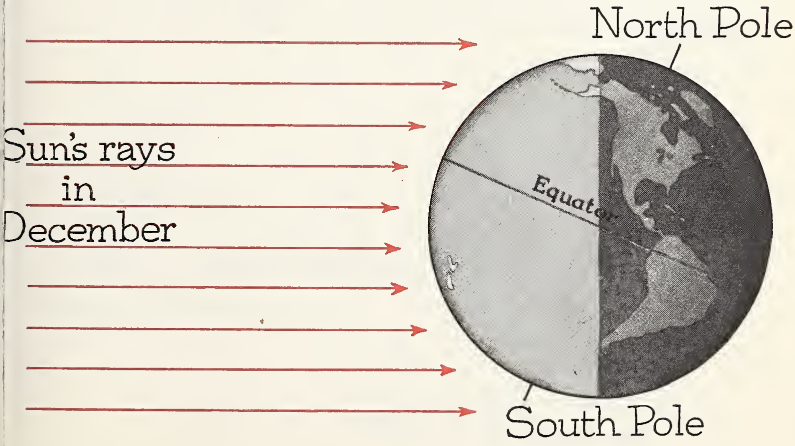


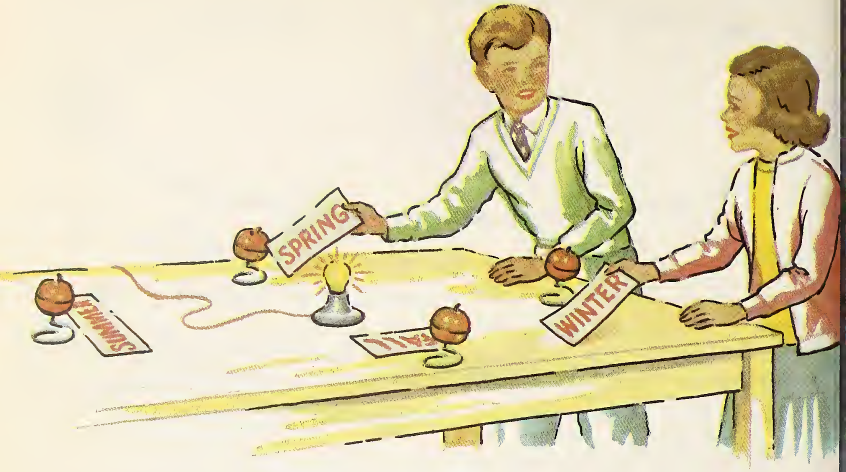


As the earth moves along its path, it is always tipped the same way. By December, when the earth is on the other side of the sun, the northern half is tipped away from the sun.

Now the nights in the north are long and the sun's path is low in the sky. This part of the earth loses more heat than it gets from the sun each day. Winter comes.

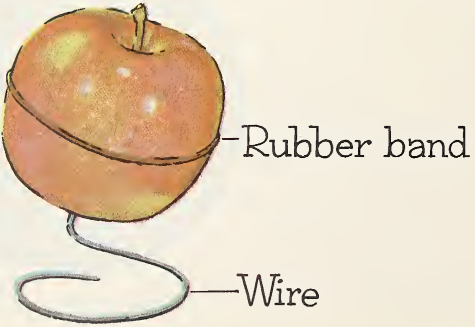
When does summer come to the southern part of the earth? When does winter come?

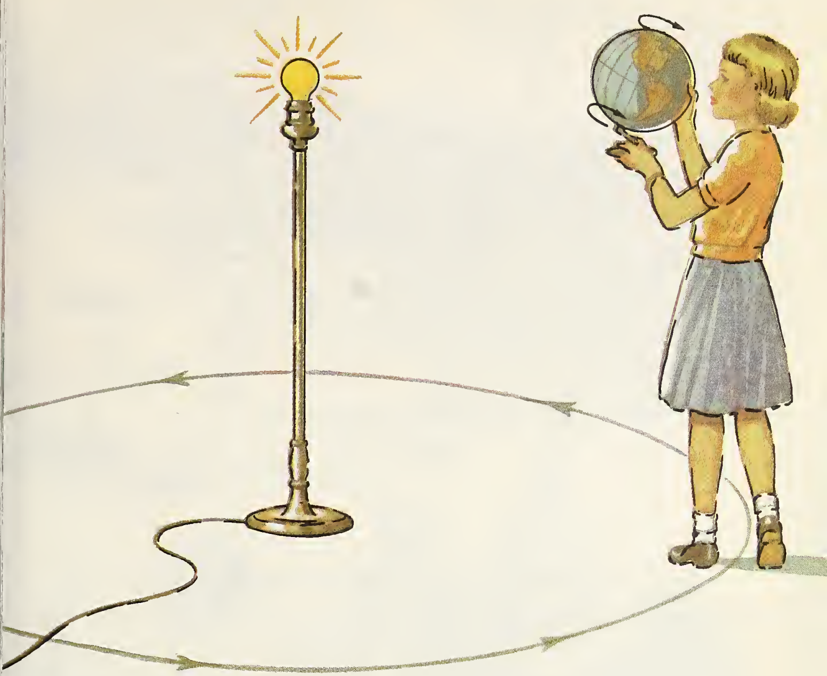




A model like the one above may help you understand the change of seasons. Use a lamp in the centre of a large table for the sun. Use apples or small globes to show where the earth is during each of the four seasons.

In which season does sunlight fall most directly on the northern part of the earth? When does it fall most directly on the southern part? When does it fall equally on the two parts of the earth?





Pretend that a lamp is the sun. Carry a globe around the lamp. Always keep the globe tipped in the same direction. Turn the globe slowly so that there is day and night on the globe.

Notice the changes in the length of the daylight hours in different parts of the globe as you carry it around the sun.

This is a scene in Australia on January first. Explain why people can go swimming there on New Year's Day.

In what other parts of the world does summer come in late December?

---

1. What motion of the earth gives us day and night?
2. What is an hour?
3. Why does noon come at different times across Canada?
4. What is standard time?
5. Why are summers warmer than winters?
6. What causes the change of seasons?
7. What are some plants and animals that change with the seasons?

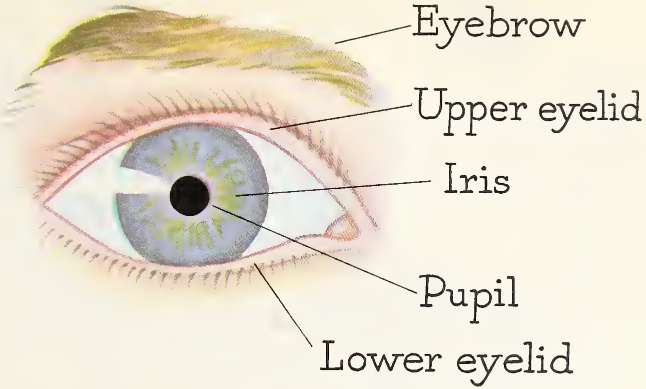
# Our Eyes

## Studying Our Eyes

The first thing you may notice about eyes is their colour. What colour are your eyes? What colours are the eyes of your classmates? What is the most common eye colour in your class?

Try to find out the colour of the eyes of your parents and grandparents. Are your eyes like any of theirs? Which of your classmates have eyes like their parents' and grandparents'?

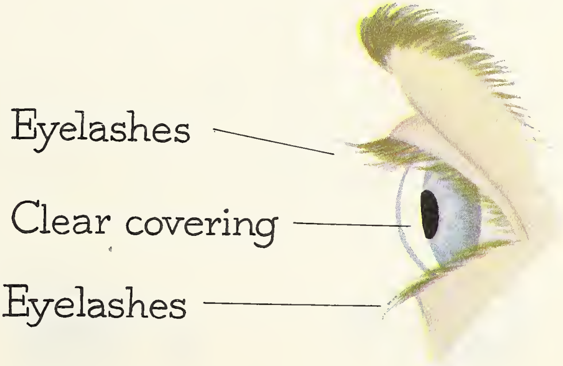
Do any of your pets have eyes somewhat like yours? What are the colours of their eyes?



Look closely at some of the parts of an eye. The coloured part is called the **iris.** The black part in the centre of the iris is called the **pupil.**

The pupil is an opening in the iris. The pupil looks black because the inside of the eye is dark. Light reflected from things around us goes into the eye through the pupil.

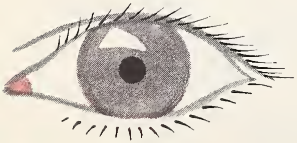
There is a clear covering over the front of the eye. Look at someone's eye from the side and you will see the clear covering.

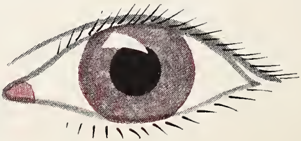


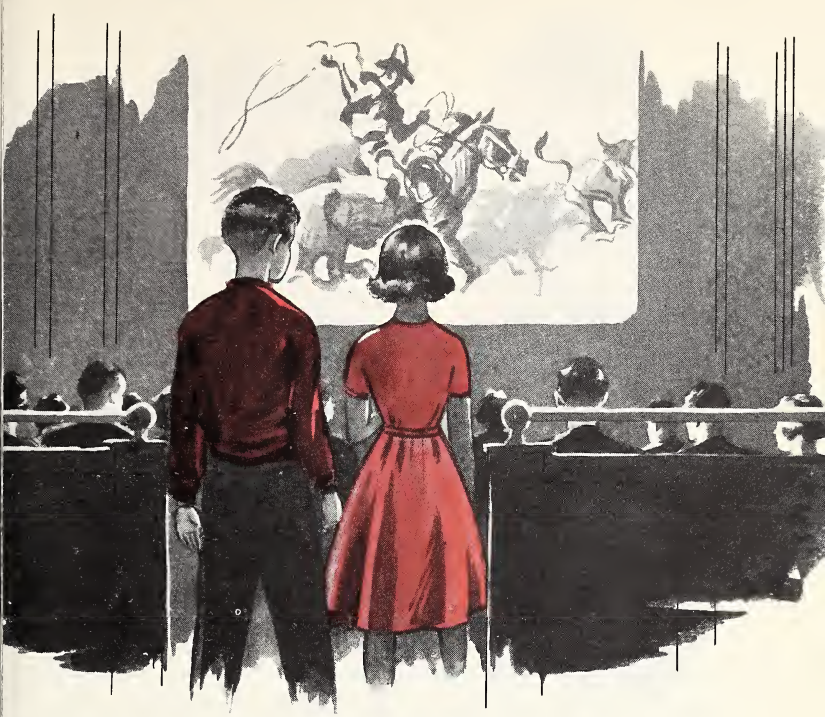
## The Iris and the Pupil

Sit so that you and a classmate can look into each other's eyes. Close your eyes and cover them with your hands. Your classmate should do the same. At the end of one minute your teacher will say "Time." Then look at the pupils of your classmate's eyes. What happens?

Pupils can change in size. They are small when the light is bright. They are large when the light is dim. When you go into a bright place, your pupils close and keep out some of the light. When you go into a dark place, your pupils open and let in as much light as possible.

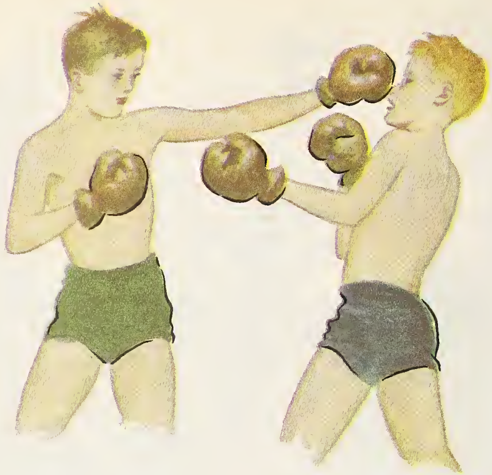






Have you noticed what happens when you go into a dark theatre on a sunny afternoon? At first you cannot see your way to a seat. After a few minutes you can see your way. Your pupils have opened and let in more light.

Do your eyes hurt when you turn on a bright light after being in a dark room? Your pupils are large in the dark room. They let in so much bright light that your eyes hurt. After a few minutes, however, you can see better and your eyes are comfortable. What happens?

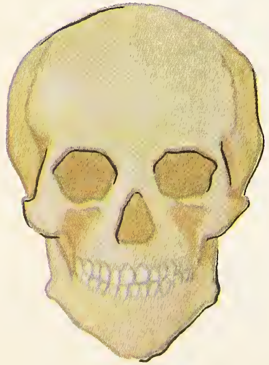


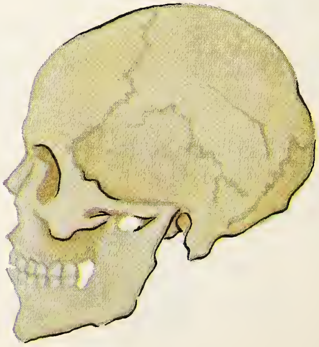
## How Our Eyes Are Protected

Press the back of your hand against your eye. What keeps your hand from hurting your eye?

Look at the drawings of the skull. Notice how well your eyes are protected by the bones around them. The eyes fit into hollows in the skull, and bones make a ring around each eye.

Touch your face with your fingers. Find the forehead bones. Find the nose bone. Find the cheek bones.





The bones around your eyes cannot keep small or sharp things from hurting your eyes. You must learn to be careful with such things.

Make up some rules for doing the following safely:

1. Handing a knife to someone else.
2. Cutting a string with a knife.
3. Whittling a stick.
4. Lighting matches.
5. Pretending to fight with sticks.
6. Running with a stick in your hand.

Make up some other rules that will help you protect your eyes.

Suppose that you are in a pillow fight and a pillow is thrown at your face. What are some of the things you do to keep your eyes from being hit? Which of these things do you do without thinking about them?

Do you usually blink your eyes when something flies toward them? Do you think about blinking your eyes or do they seem to close by themselves?

We do many things without thinking about them. Watch someone's eyes when he does not know you are looking. Does he blink his eyes? Do you know of other things people do without thinking?

Look at the hair growing around someone's eyes. There is an eyebrow over each eye. Some people think that eyebrows help keep sweat from running into the eyes on hot days. Eyebrows might also keep rain from running down into the eyes.

The hairs on your eyelids are called eyelashes. Eyelashes help keep dust from your eyes when the wind is blowing. You can nearly close your eyes and look through the eyelashes. The eyelashes make a screen that helps keep out dust.

Ask someone to nearly close his eyes. Notice how the eyelashes fit together.

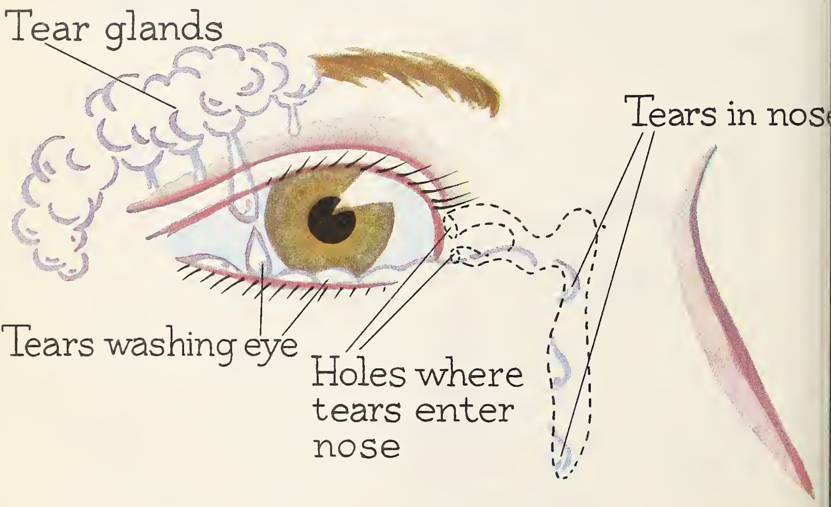
## Tears

There are tears in your eyes all the time. A gland near the outer corner of each eye is always making tears. The tears flow across your eyes as you blink. Then the tears run into small holes to your nose.

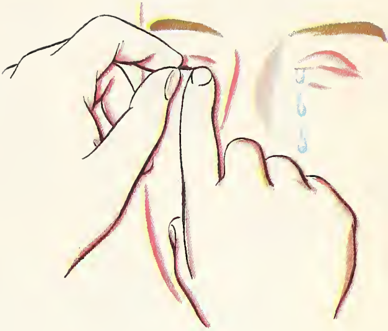
Look at your eyes in a mirror. You will see the two small holes in the inside corner of each eye.

Tears keep your eyes from drying out. They also wash dust from your eyes.

Sometimes you make a great many tears. Where do they go? Do you know why you must blow your nose when you cry?



## Removing Dirt

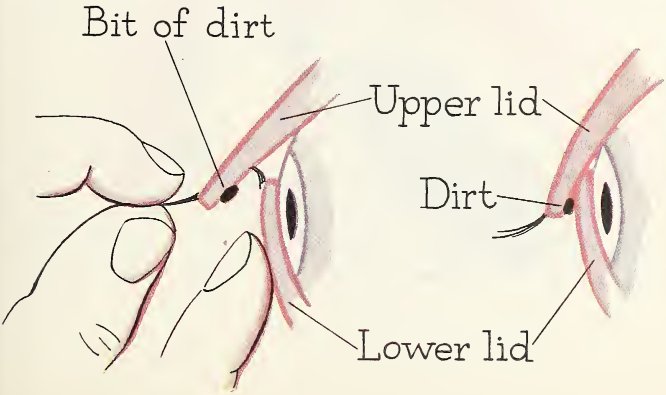


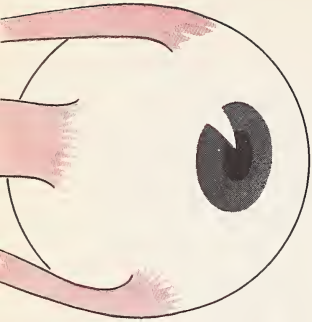
Many tears come into your eyes when you get a bit of dirt in them. How does crying help take out the dirt?

You should not rub your eyes when there is dirt in them. The dirt may be sharp and you will scratch the inside of the eyelid or the eyeball.

It is often easy to take out a bit of dirt that gets under the upper eyelid. Take hold of the upper eyelashes and pull the upper eyelid out over the lower lid. Then let it slide back over the lower lid. The lower eyelashes will often brush off the bit of dirt.

Sometimes you will need help in taking dirt from your eyes. A doctor or a nurse knows best how to do this.



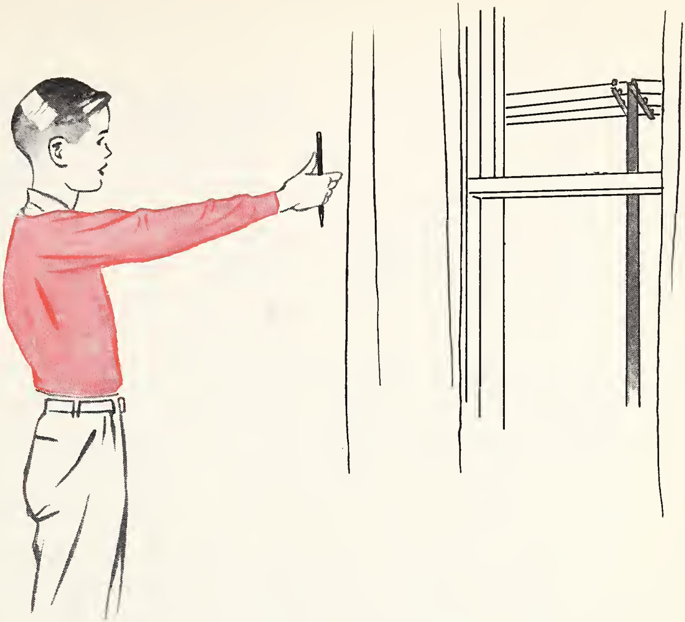


## Moving the Eyes

An eye is shaped much like a ball. You can see only a small part of the eye between the eyelids. The rest of it is hidden inside the head.

Watch someone moving his eyes. Move your own eyes from side to side and up and down. Move a pencil upwards. How far can you watch it without moving your head? Move the pencil to one side and then the other. How far can you watch it without turning your head?

There are muscles fastened to each eyeball. Three muscles are shown in the picture on this page. These muscles turn the eyeball so you can look in different directions without turning your head.

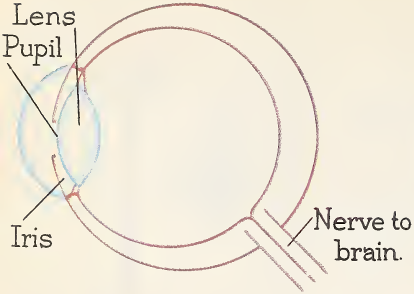


Your eye muscles also turn your eyes toward each other when you look at something close. When you look at something far away, the muscles turn your eyes until they both look straight ahead.

Face a window and hold a pencil at arm's length. Look just over the pencil at a pole or a tree outside the window. How many pencils do you see? Now look at the pencil. How many poles do you see?

When you look at the pole, neither eye is turned toward the pencil. You see two pencils, one with each eye, in different places. When you look at the pencil, both eyes turn toward it and you see only one pencil.

Watch someone's eyes as he does this experiment.

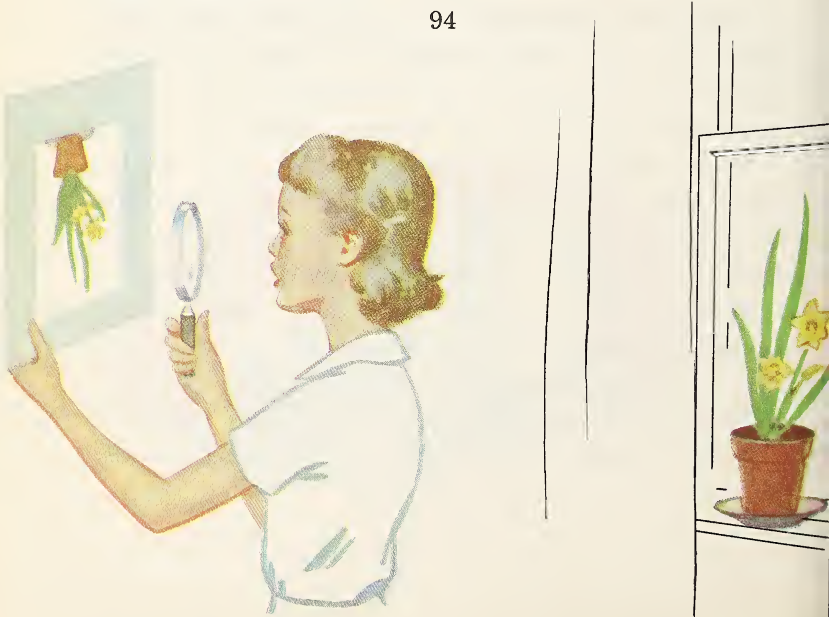


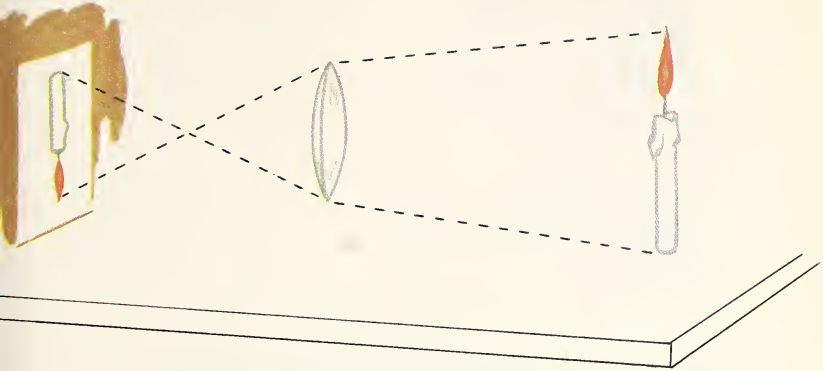
# The Lens in the Eye

There is a lens inside each eyeball. It is just behind the pupil. The lens has the shape of a magnifying lens.

An experiment with a magnifying lens will show what the lens in your eye does. Stand with your back to a window. Hold the lens in front of a sheet of paper and move it backwards and forwards. You will be able to make a picture of the window on the sheet of paper.

The lens in your eye makes a picture on the back of the eyeball. There are many nerves in this part of the eyeball. The nerves lead to your brain and let you know what you see.



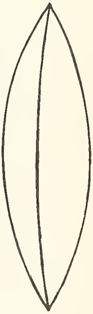


The lens in your eye is unlike a glass lens in one important way. You can make the lens in your eye thicker or thinner.

This experiment shows what thick lenses and thin lenses can do. You will need two lenses, one much thicker than the other. Set up the materials shown above and darken the room. Move the candle back and forth until its picture shows on the paper.

Then change the lenses. Hold the second lens in the same place that you held the first lens. Move the candle back and forth until its picture shows on the paper.

The thick lens makes a picture when the candle is close to the paper. The thin lens makes a picture when the candle is farther away.

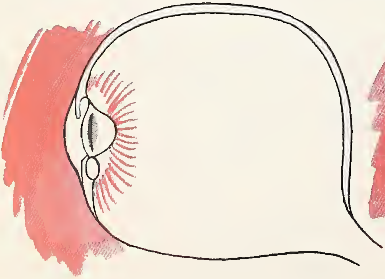


## Changing the Shape of the Lens of the Eye

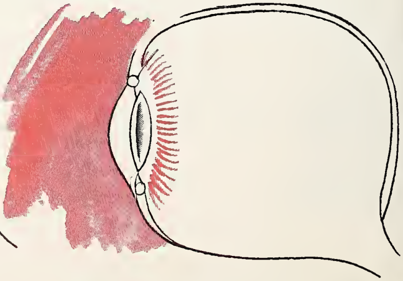
Shut one eye and hold a pencil near the other eye. Look first at the pencil. Then look at something far away. Sometimes you will feel a change inside your eye as you look from one thing to another. You are making the lens in your eye thicker and thinner.

Can you see the pencil clearly when you are looking at something far away? Can you see far away things clearly when you are looking at the pencil?

There are muscles around the lens in the eye. The muscles can make the lens thicker. The closer the things that you are looking at, the thicker the muscles make the lens.



Looking close

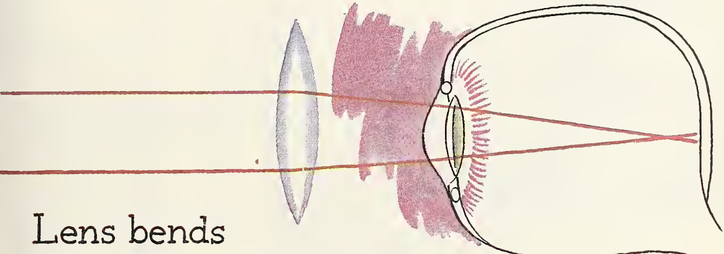


Looking far away

Some people have eye muscles that do not work perfectly. If they cannot make the lenses in their eyes thin enough, they cannot see distant things clearly. These people are "near-sighted." If they cannot make the lenses in their eyes thick enough, they cannot see nearby things clearly. These people are "far-sighted."

Such people need glasses. The lenses in the glasses help such people see more clearly.

Every person should have his eyes tested by a doctor. The doctor can tell whether the person needs glasses. He will also look for diseases or injuries to the eyes and treat any that he finds.



Lens bends
light a little

## Good Light for Seeing

Lens muscles must work hardest when you are looking at things close to you. Therefore you should be most careful when you are reading or doing close work.

You should not read or do close work too long at one time. Rest your eyes if you can by going outdoors to work or play. If you cannot go outdoors try to do some other kind of work.

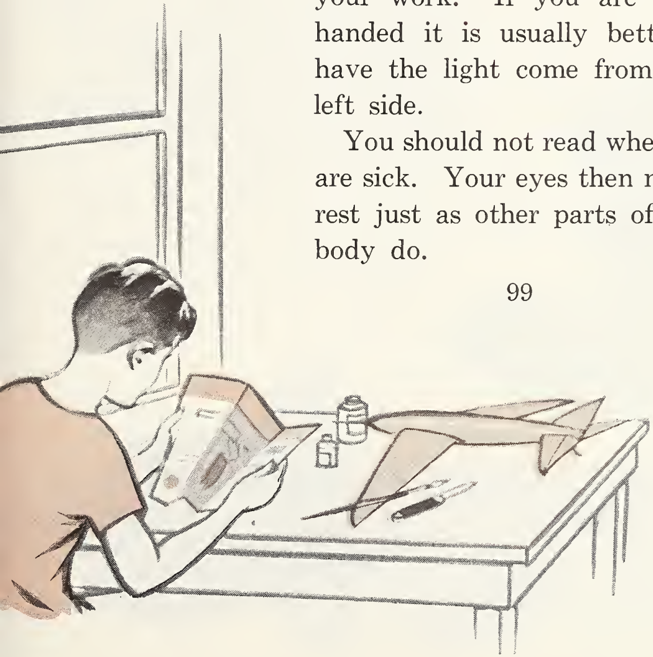
Try to have a good light when you read or do close work. The best light is outdoors in the shade of a house or a tree. But do not let sunlight fall on your book because it will reflect into your eyes.

At night use several lights in different parts of the room. Then you will have a strong light on your work and there will not be many shadows.

When you read sit so that the strongest light comes over your shoulder. Then the light will not reflect from the book into your eyes.

Try not to have shadows on your work. If you are right-handed it is usually better to have the light come from your left side.

You should not read when you are sick. Your eyes then need a rest just as other parts of your body do.



Rabbit

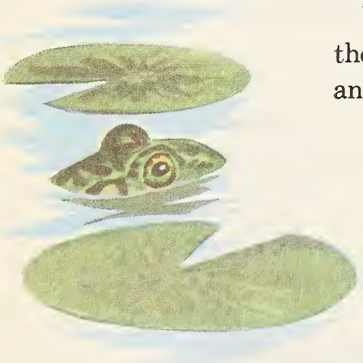
## Animal Eyes

Many animals have eyes somewhat like our own, although there are usually many differences, too.

A rabbit's eyes are placed at the sides of its head. The rabbit can see nearly all the way around without turning its head. How does this help the rabbit?

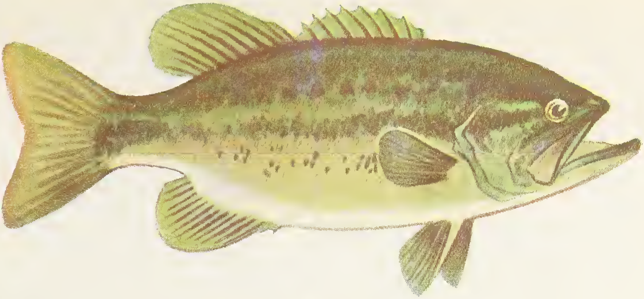
The eyes of a meadow mouse are near the top of its head. How does this help the meadow mouse?

Where are our eyes? Where are the eyes of a cat, a robin, a squirrel, an owl, and a frog?



Frog

Meadow mouse



Bass

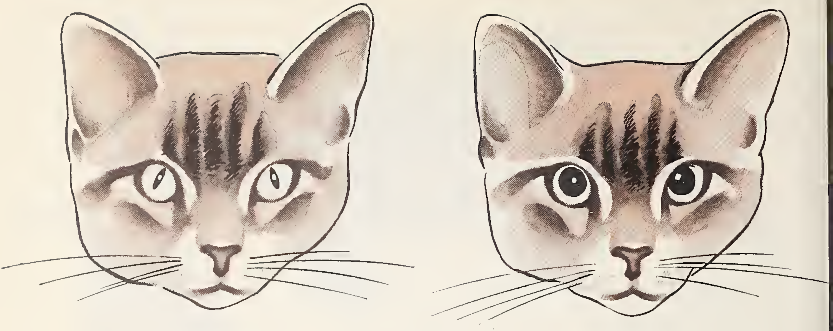
Look at the eyes of a goldfish or some other fish. Does the fish have eyelids? Does it close its eyes? Can it move its eyes?

Have you noticed that you cannot see clearly when you are under water? Probably a fish cannot see clearly when it is in the air. The eye lenses of animals that live in the water are usually thicker than the eye lenses of animals that live in the air.

Fish that live in dark, muddy water, such as catfish, may have small eyes. They seem to find their food by smell or taste rather than by sight. Fish that hunt living animals usually have large eyes.

There are a few kinds of fish that live in caves where there is no light. These fish are often blind. They have eyes, but their eyes are useless.

Catfish



## Eyes of Animals at Night

Animals that are active at night often have large eyes. The pupils of their eyes become very large in the dark. How may this be of help to the animals?

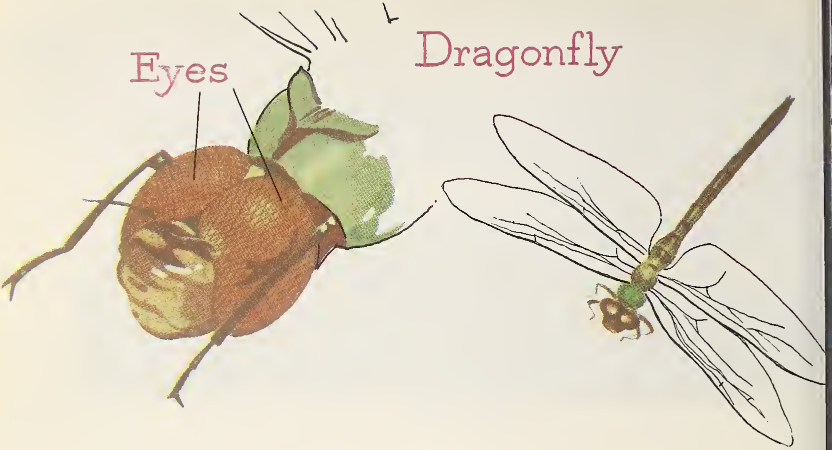
Study a cat's eyes. Notice the pupils on a bright day. What shape are the pupils? Put the cat in a room where the light is dim. What happens to the pupils?

Name some other animals that are active at night. Which ones have large eyes?

Have you ever seen a pair of eyes shining along the road at night? Did you see the animal?

Some people think that such eyes give off light much as a flashlight does. You will see these eyes shining, however, only when the animal is facing a bright light. The light reflects from a layer in the back of the animal's eyes. You see reflected light.

What colours have you seen reflected by animals' eyes at night?



Insects have eyes that are much different from our own. Many insects have more than two eyes. Often two of their eyes are made up of hundreds of tiny prisms. We are not certain just how things look through all these prisms, but we do know that some of these insects have good sight.

---

1. Where does light enter the eye?
2. What is the shape of the lens in an eye?
3. What are some ways our eyes are protected from being hit?
4. What happens to your eyes as you go from a dark place to a brightly lighted place?
5. Why are your eyes under greatest strain when you read or do close work?
6. List some rules for the care of the eyes.
7. Name some animals that can see well at night.

# Making Work Easier

## Dividing Work

Suppose that you must move a large pile of bricks. You are not strong enough to lift the whole pile at once. What would you do?

How could a small child move the pile of bricks? How could a strong man move them? Who would do the work faster?

Here we see an important way for doing work more easily. We can divide work into small parts and do one part at a time. We do the same amount of work but we do it more easily. We lose speed as we make work easier.

This man is dividing his work into small parts. He is moving a pile of dirt one shovelful at a time. He will stop filling the wheelbarrow before it becomes too heavy to move easily.

How could a small boy move the pile of dirt?

Make a list of other kinds of work that we can do more easily by dividing each into small parts.

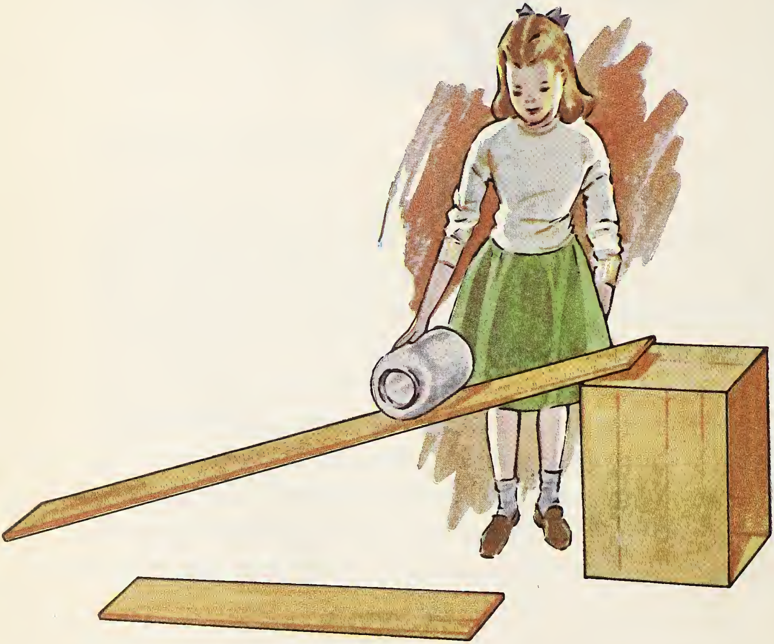
We can often use our minds to help us do something more easily. We look for ways of doing the work more slowly. We can save in force by giving up speed.

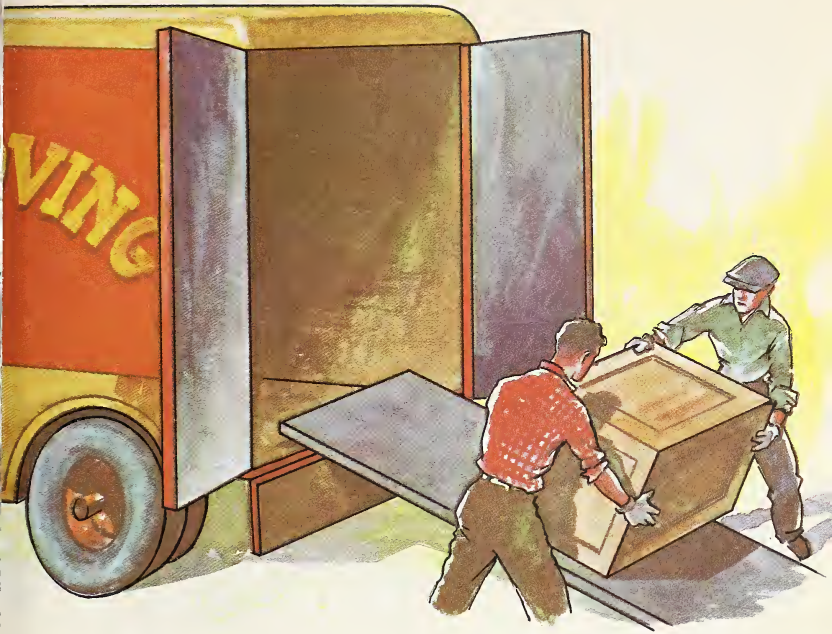
## Using a Slope

Find a long board and a short board. Put one end of the short board on a box.

Fill a gallon jar or a round can with sand. Lift it straight up. Roll it up the short board. Roll it up the long board. Is it easier to lift the jar straight up or roll it up a board? Which board made the work easier?

This experiment shows a way to make work easier. We use less force when we roll the jar up the long board. We need less force when we do work more slowly.

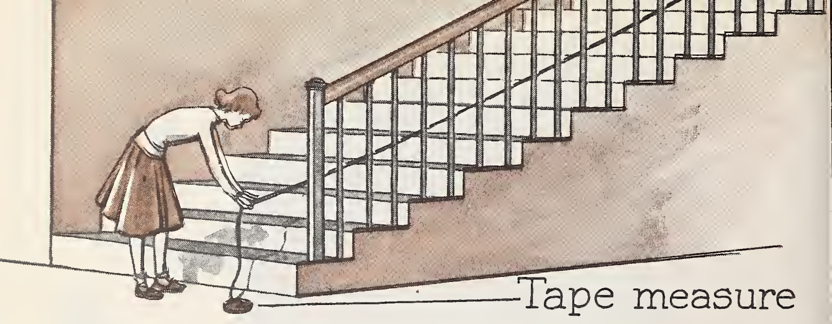




These men have found a way to move some heavy boxes into the truck. They are pushing the boxes up a long plank. By moving the boxes slowly, their work is made easier.

How could the men do their work if they were stronger? How far would they have to move the box if they could lift it straight up? How far do they move the box when they use the plank? Which way takes longer? Which way is easier? Have they done the same amount of work each way?

Have you ever seen people lifting heavy things this way? Where? Have you ever tried it?

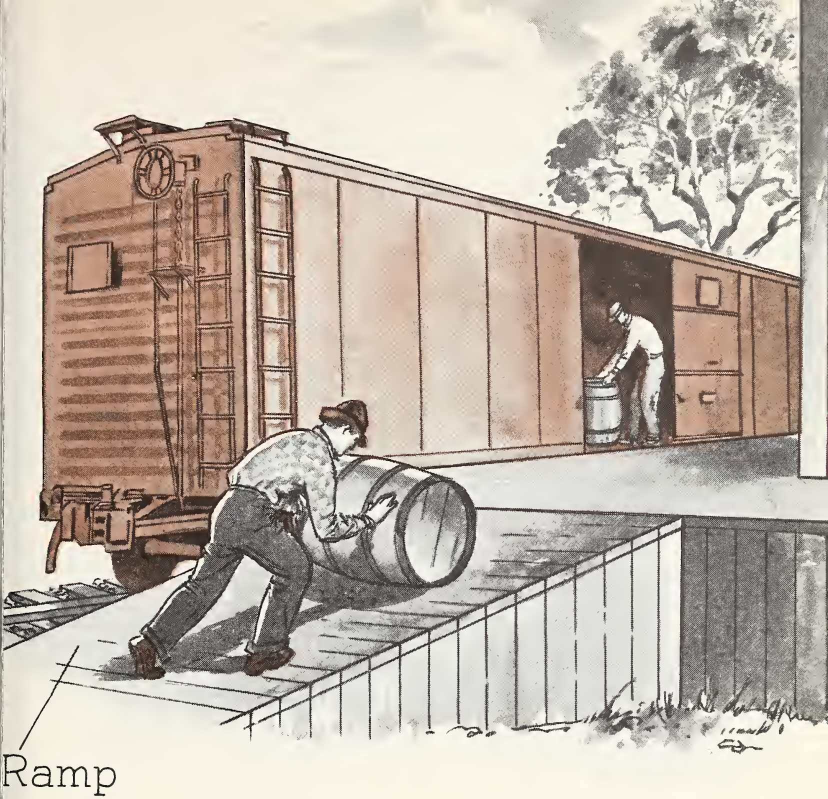


A stairway is a slope with steps on it. What would we use if we were to climb straight up? Why is it easier to use stairs?

Study the stairs in your school. Measure the height straight up. Measure the length of the stairs. How far do you move along the stairs when you raise your body one foot upwards?

Study stairs in other places. Find some stairs that are steeper than your school stairs. Are they harder to climb? How would you build stairs for old or very weak people?

Sometimes there is not enough room to build long, straight stairs. Then winding stairs are built. Such stairs may be long without taking up much space.

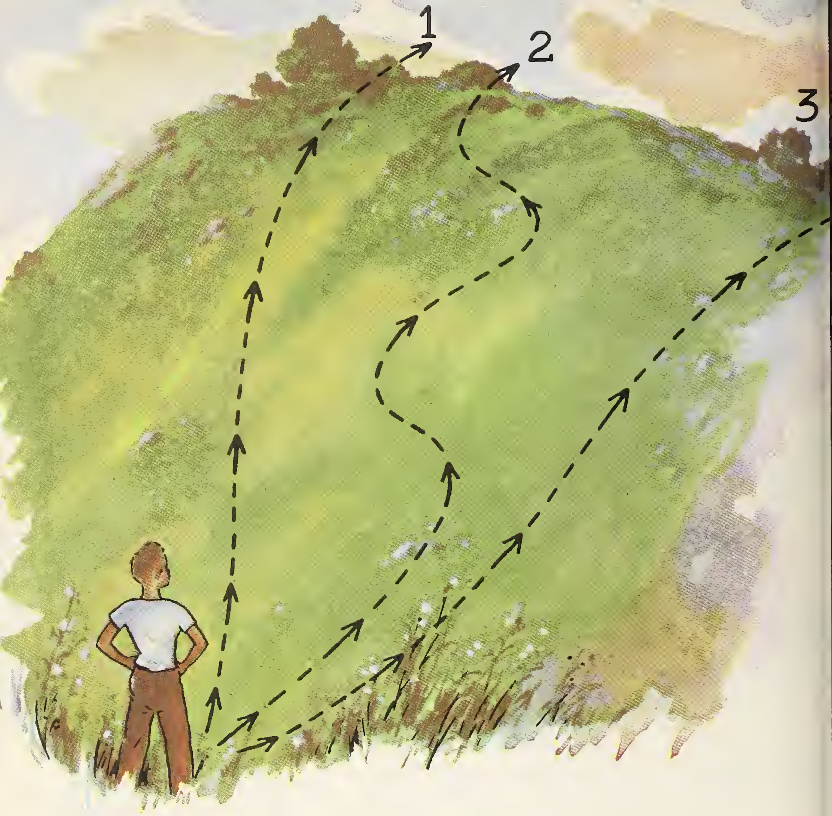


Sometimes people must raise things that roll or have wheels. Stairs cannot be used to raise such things.

Slopes can be built without steps. Such slopes are called ramps. The picture above shows a ramp.

Why are ramps sometimes built in hospitals? Why are there ramps in many garages? Are there any ramps in your school?

To raise very heavy things, would you build a long or a short ramp? Why?

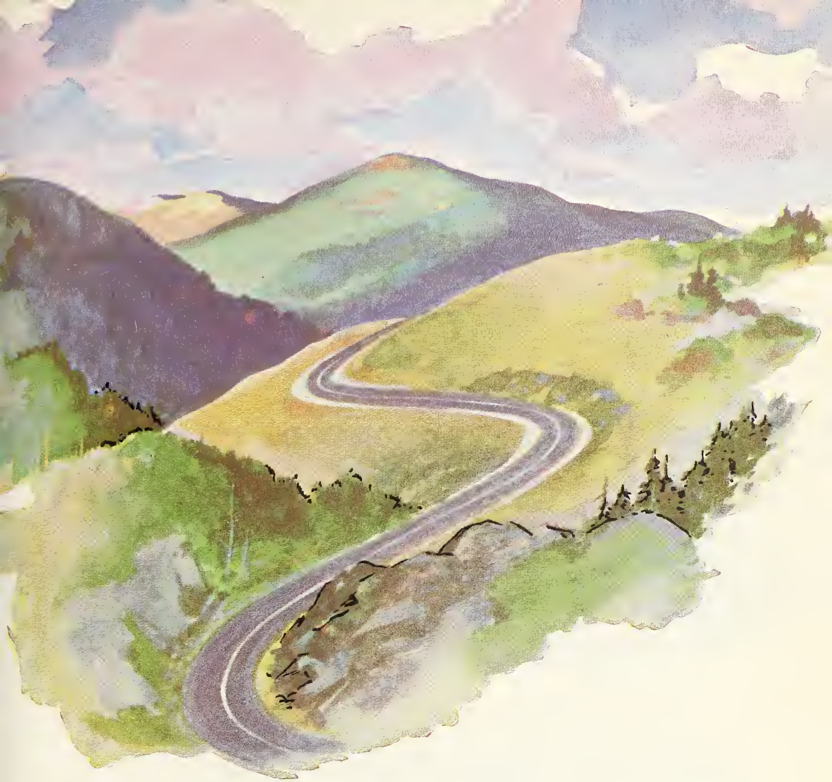


This boy wants to climb the hill. What is the quickest way?

If you were going to make a path for a bicycle, where would you make it?

Study a small, steep hill if you can. Measure the shortest way up the hill. Measure some other ways. Climb up the different paths and see which is easiest.

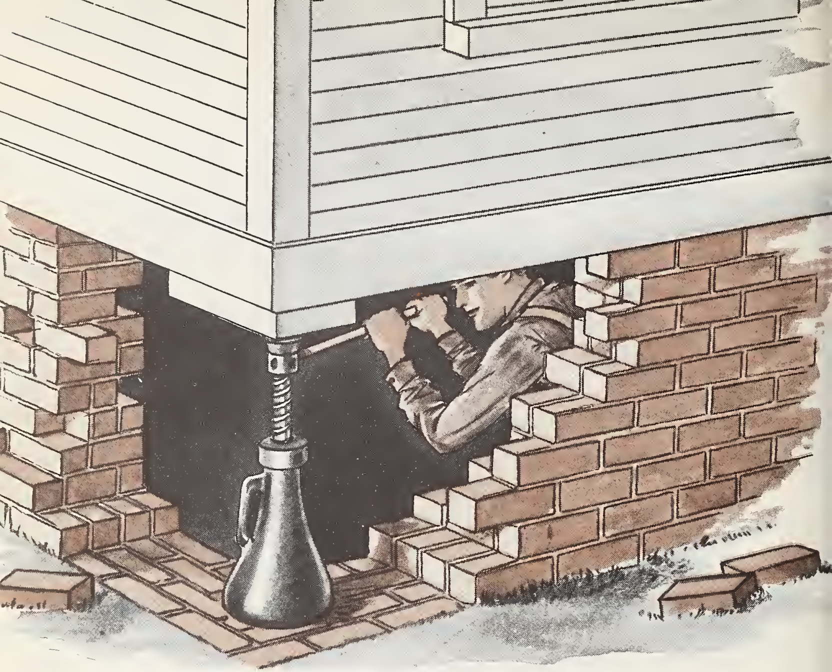
Make a path that winds back and forth. Measure it. Is it easy to climb?



A road that climbs a steep mountain often has sharp bends in it. Can you tell why the road is made this way?

Winding roads like this are made in most places where there are mountains. Look for pictures of roads made this way.

Look for pictures of railroads that are built over mountains. Do the railroads go straight up or do they wind up the side of the mountains?



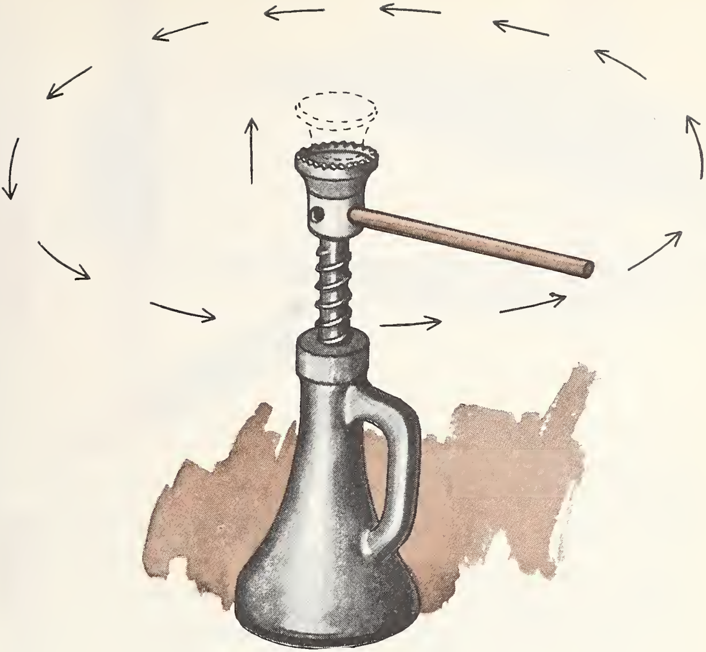
## Screws to Make Work Easier

This man is lifting one corner of a house. He is not strong enough to lift it without help. He is using a tool called a **jack-screw.**

The man pushes on the bar that turns the screw. As the screw turns, it rises and pushes up the house.

Have you ever seen a jack-screw being used? Where? Sometimes you will see jack-screws being used to raise heavy cars and trucks.

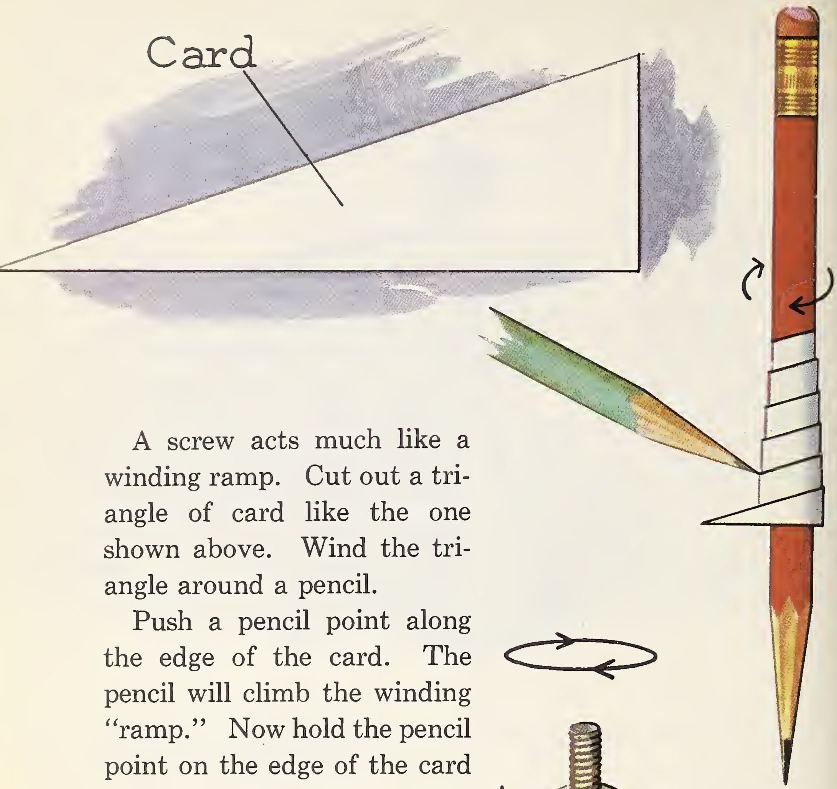
Try to find a jack-screw that you can bring to school and show your classmates.



This drawing shows why a jack-screw helps a person raise a heavy load.

The large black circle shows how far the man must move to turn the screw once. The black arrow in the centre shows how far the house is raised for one turn of the screw. The man must move a long way to raise the house a short distance. He does the work very slowly.

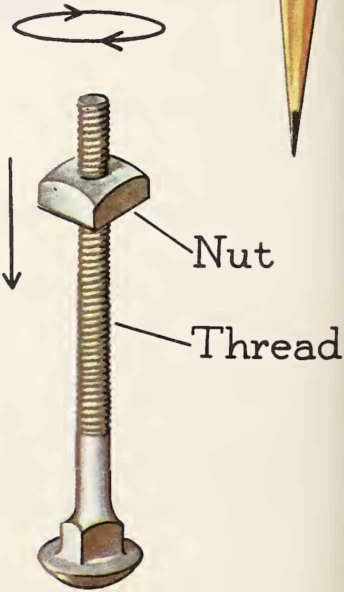
Such tools never give us something for nothing. The man seems to be made stronger when he uses the jack-screw, but he pays for it by moving farther. He does his work more slowly.

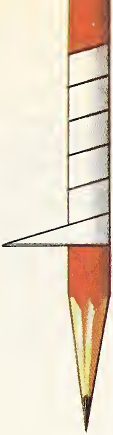


A screw acts much like a winding ramp. Cut out a triangle of card like the one shown above. Wind the triangle around a pencil.

Push a pencil point along the edge of the card. The pencil will climb the winding "ramp." Now hold the pencil point on the edge of the card and turn the other pencil. What happens?

Study a bolt. The thread of the screw is a winding ramp. Follow it by moving a pin point along it. Turn the nut on the bolt. The nut will climb up or go down the winding ramp. What happens if the nut is held still and the bolt is turned?

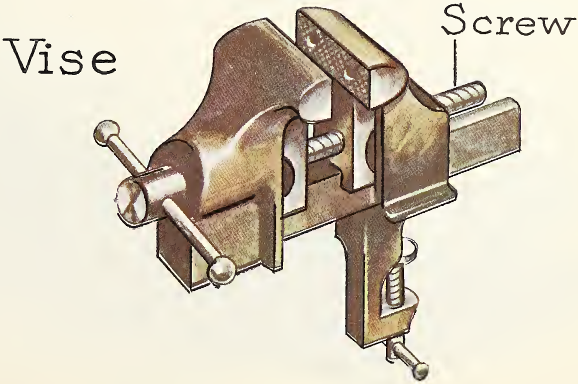


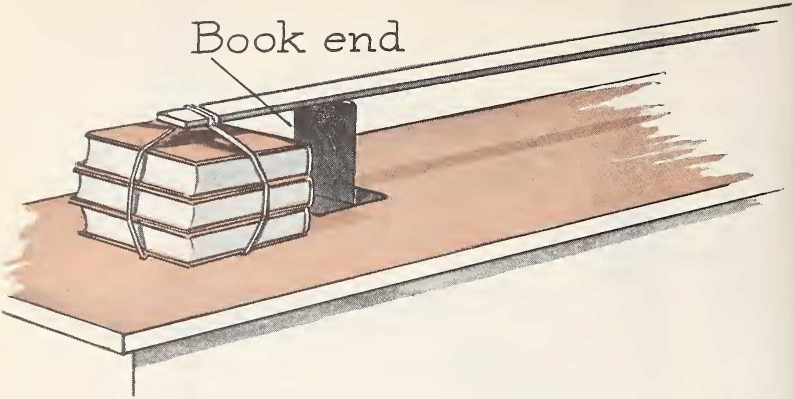


Cut out triangles of different slopes and wind each one around a pencil. What is the difference in their appearances?

A screw with threads close together has a gentle slope. It does work slowly and easily. Such screws are used to raise heavy loads.

Look for some tools that use screws. Study a meat grinder, a vise, and a wood auger. What does the screw do in each one?



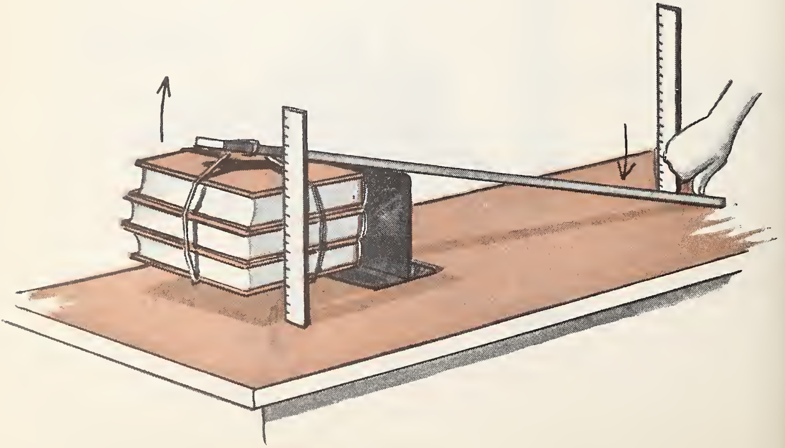


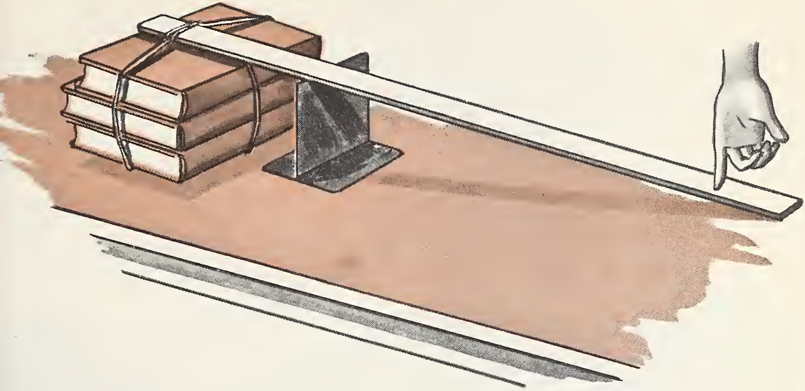
## Experiments with Levers

Tie some books together with a cord. Fasten them to a stick and put a support under the stick as shown above. Push down on the stick. Then lift the books without using the stick. Which way is easier?

The stick is used as a lever. Levers are often used this way to move heavy things more easily.

Measure the distance you raise the books with the lever. Measure the distance you push down on the lever. Which is greater? Did the lever make you work through a longer distance?

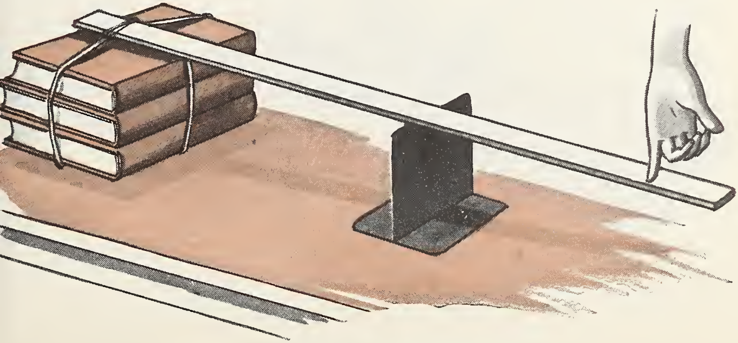


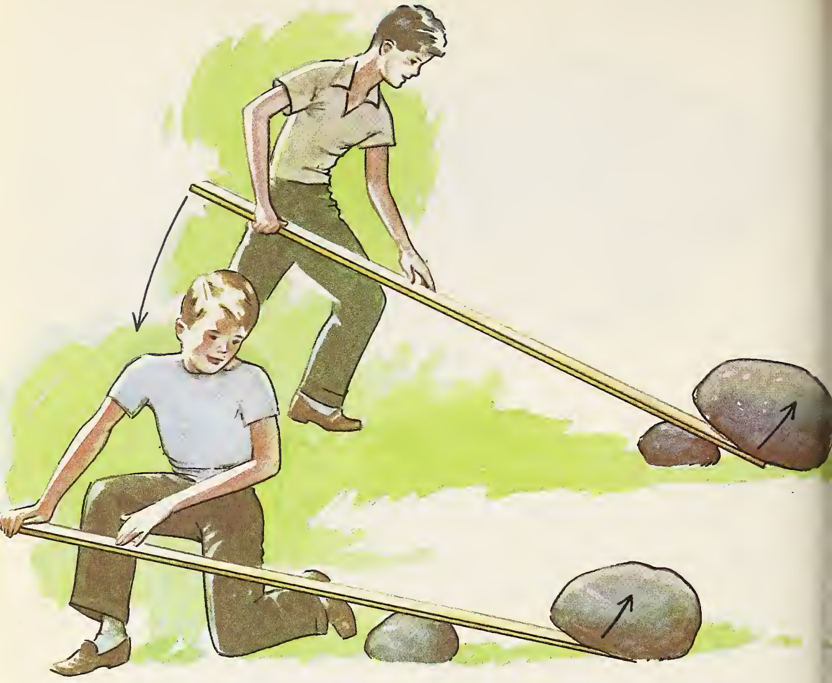


Move the support to different places. Each time raise the books by pushing down with one finger. Where is the support when the books are raised most easily?

Measure the distance the books are moved each time. Measure the distance your finger moves each time. Notice that when your finger moves farther than the books, the lever makes your work easier.

When the books move up farther than your finger moves down do you have to push harder?





## Using Levers

A lever is often used to lift heavy things. In the picture each boy is lifting a rock with a lever. Each boy is trying it a different way.

Try the experiment yourself. Use a board for a lever. Use a rock or a box of books for the load. Try the support for the lever in different places. Where is the support when the load is lifted more easily?

A lever makes work easier if the end that is pushed moves farther than the load moves. The more slowly the work is done, the easier it is to do.

A hammer is used as a lever when it is pulling a nail. The end of the handle moves much farther than the nail moves. Therefore, a small force on the handle makes a strong pull on the nail.

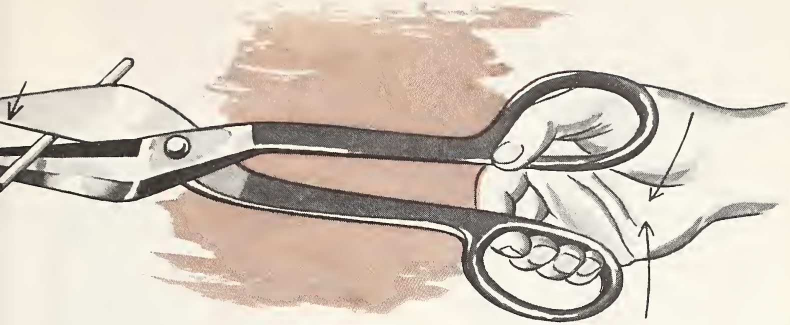
Try to pull a nail without a hammer. Then pull the nail with the hammer. Try to pull nails with your hand at different places on the handle of the hammer. Where is your hand when the nail comes out most easily?

Try to experiment with a wheelbarrow. If you cannot use one, use a long board with one end resting on a box.

Put a load as near the wheel as you can. How far does the load rise when you raise the handles? How far do your hands rise?

Put the load as far from the wheel as you can. How far does the load rise when you raise the handles? Does the load rise more or less than it did before?

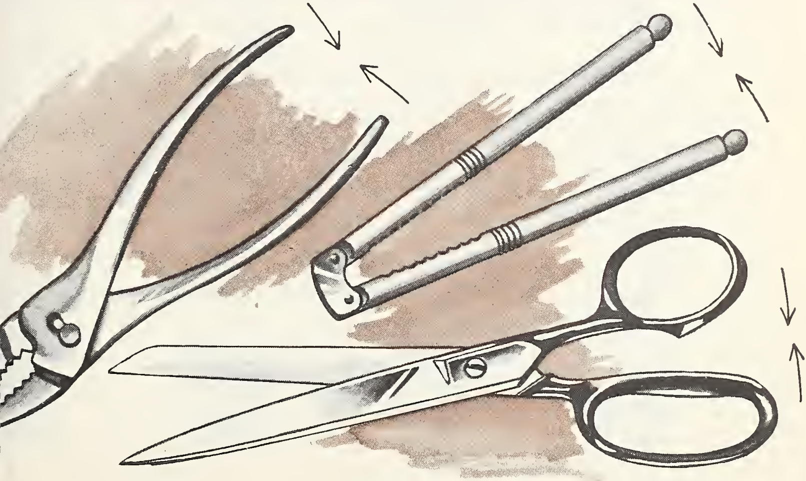
Where is the load when it is most easily raised?

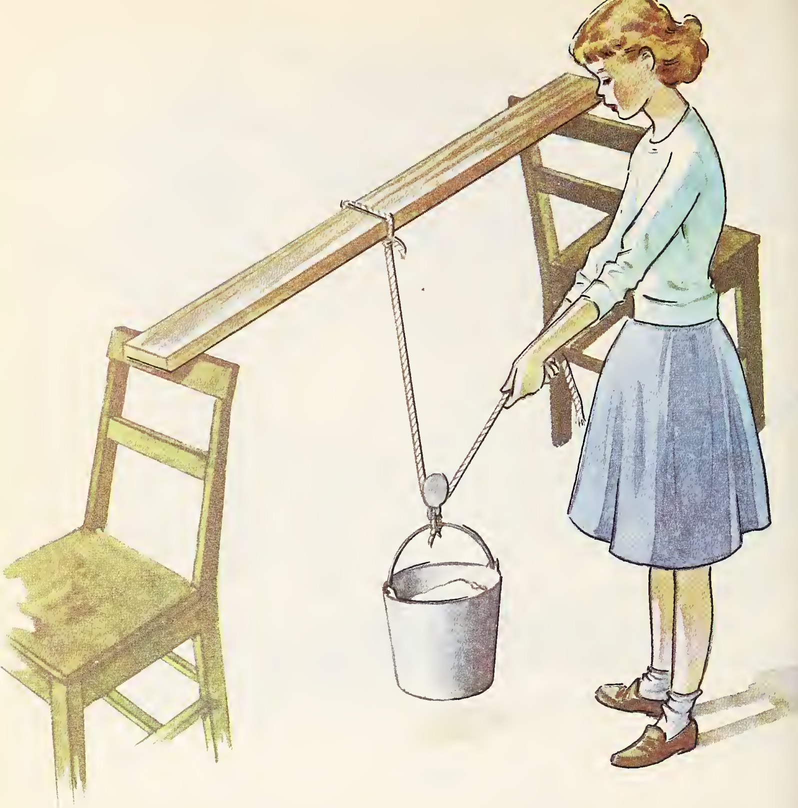


Shears like these are used to cut metal. Do the blades or the handles move farther?

Cut some wire with a pair of metal shears. Put the wire at different places between the blades. Where is the wire when it is most easily cut?

Shears are like a pair of levers working together. Name some other tools that are somewhat like shears. How is each one used? Try out as many of them as you can.





## Pulleys to Help Us

Find an awning pulley and fasten it to a pail of sand. Put a cord through the pulley and fasten one end of the cord to something higher than the pail.

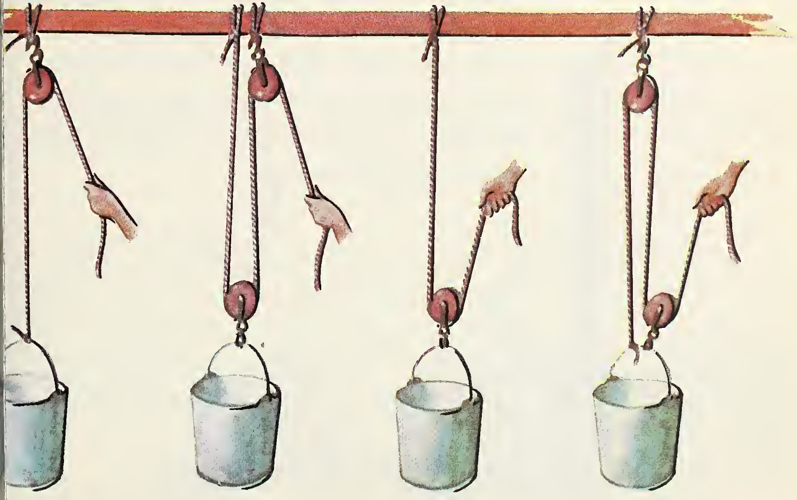
Raise the pail by taking hold of the handle. Then raise the pail by pulling the cord. Which is the easier way?

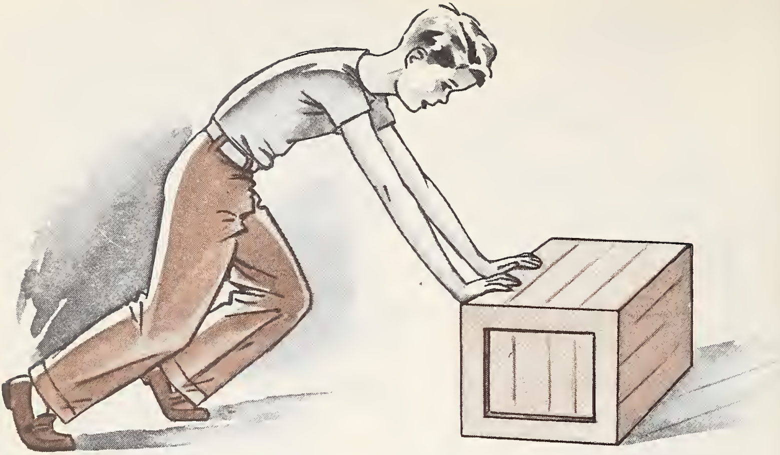
Pull the cord until you have raised the pail one foot. How far did your hand move?

# Double pulleys

Find some more pulleys and use them in the ways shown below. Each time measure the distance your hand must move to raise the load one foot. Find out which ways you can use the pulleys to make work easier.

You will often see pulleys being used in some of these ways. You can always tell whether they are making the work easier by noticing whether the hands that do the pulling move farther than the load moves.



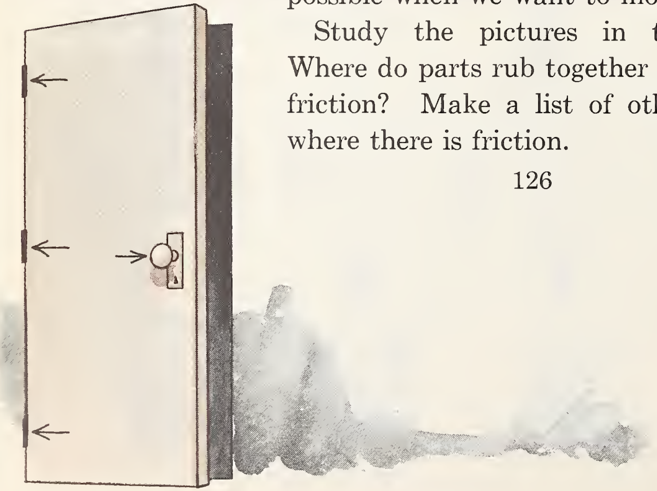


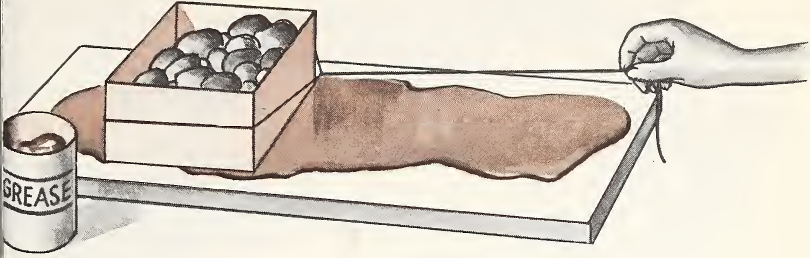
## Making Friction Less

You know that it is hard to push a heavy box across the floor because the box rubs on the floor. The harder the box rubs, the harder it is to push it.

We say that there is **friction** when two parts rub together. Friction makes it hard to move the parts. We try to make the friction as small as possible when we want to move things.

Study the pictures in this unit. Where do parts rub together and cause friction? Make a list of other places where there is friction.

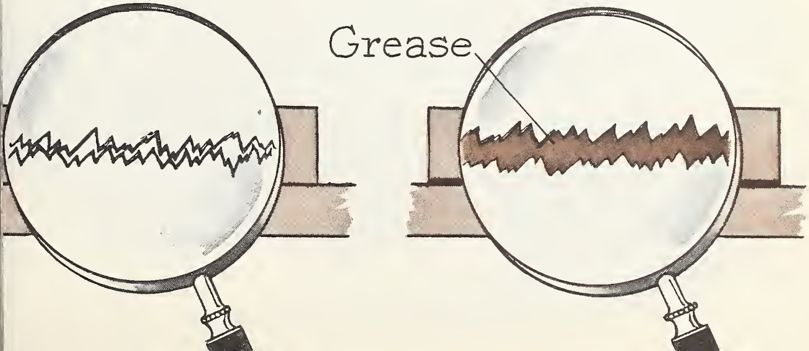


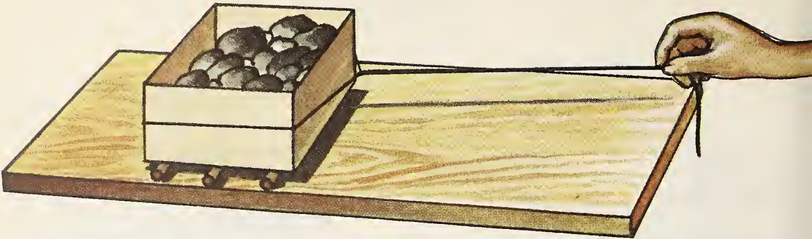


Put a load of stones in a small wooden box and pull it along a board. Notice how hard it is to pull the box. The reason there is friction between the box and the board is because the wood is rough. The rough places catch on each other. Even if we make the boards as smooth as we can, there are still rough places that catch each other.

Cover the board with grease and pull the box along the board. Notice the difference. Putting grease or oil on parts that rub together makes friction less and work easier.

Grease fills in the rough places on sliding parts and keeps the sliding parts away from each other. The picture below shows how grease between two rough parts makes the amount of friction smaller.

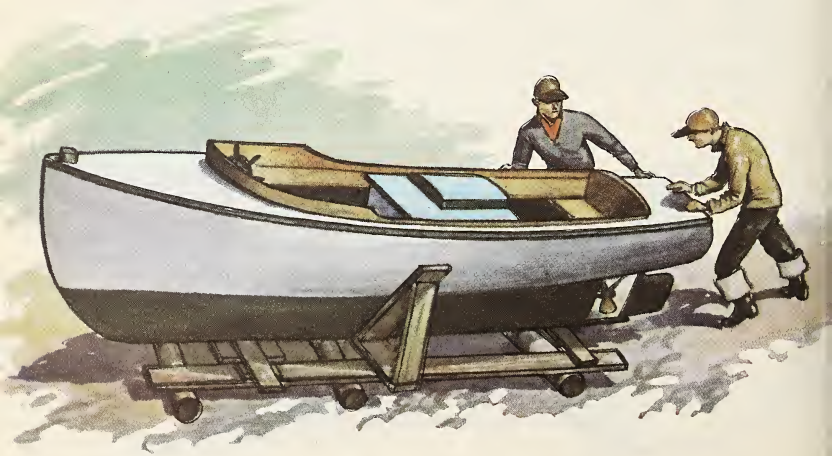


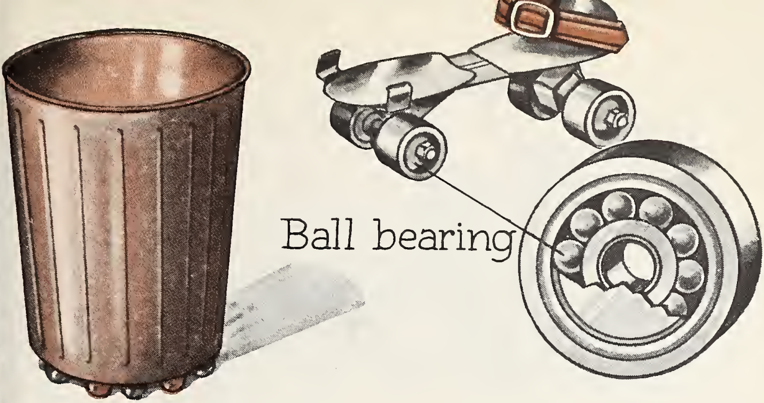


Put a load of stones in a small box and pull it along a board. Notice how hard it is to pull the box. Now put round pencils or round sticks under the box. Notice how much more easily the box moves.

Friction between rolling parts is less than friction between sliding parts. That is the reason why we use wheels on wagons and automobiles. We slide things only when there is little friction, such as when we pull a sled over ice.

The picture below shows two men moving a heavy boat into the water. What are they using? Why is this easier than sliding the boat across the beach?



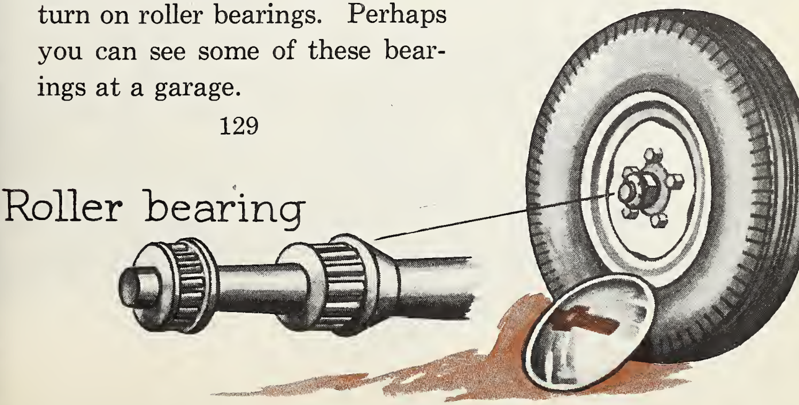


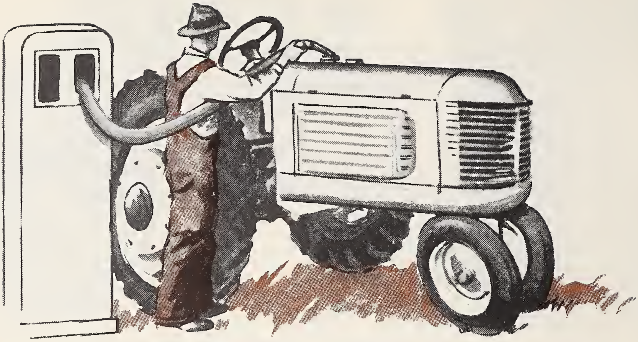
Wheels rub on their axles when they turn. One way to make the friction less is to put small balls between a wheel and its axle. This is called a **ball bearing.** Sometimes small rollers are used instead of balls. This is called a **roller bearing.**

Set a wastebasket on some marbles. Turn the basket around and notice how easily it moves. There is less friction when the basket rolls on the balls than when it slides on the floor.

You will find ball bearings in many wheels. Look for them in roller skates. You can also find them in bicycle wheels and pedals.

Some automobile wheels turn on ball bearings. Other wheels turn on roller bearings. Perhaps you can see some of these bearings at a garage.





## Using Stored Energy to Make Work Easier

We use stored energy to help us with our work. We use the energy stored in gasoline and coal. List some ways we use the energy of gasoline and coal.

Running water also has energy. Explain how we use this energy.

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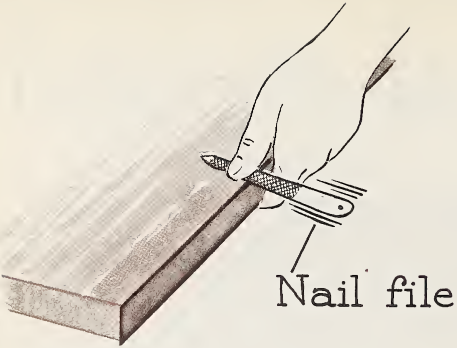
1. Why do roads wind up mountains instead of climbing straight up?
2. How does a jack-screw help us raise heavy loads?
3. What is an easy way to raise a heavy barrel into a truck?
4. Why are handles of metal shears longer than the handles of cloth shears?
5. Where is the best place to put the support of a lever when you must raise a heavy load?
6. Why are oil and grease used in automobiles?
7. What can you do to move a heavy box across a floor more easily?

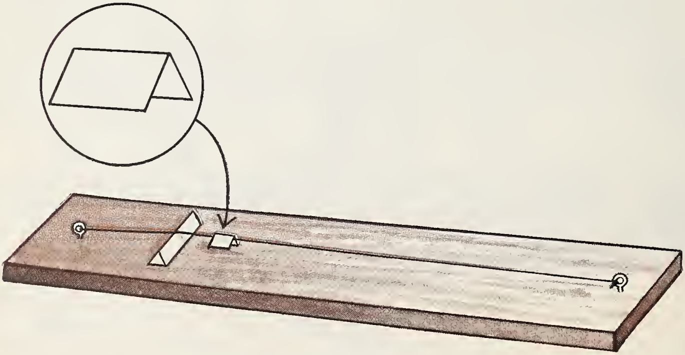
# Musical Sounds



## The Cause of Sound

Hold one end of a nail file flat against a table top. Pull down the other end of the file and let it go. You will hear a sound. You will also see the file moving rapidly up and down. We say that the file **vibrates.**

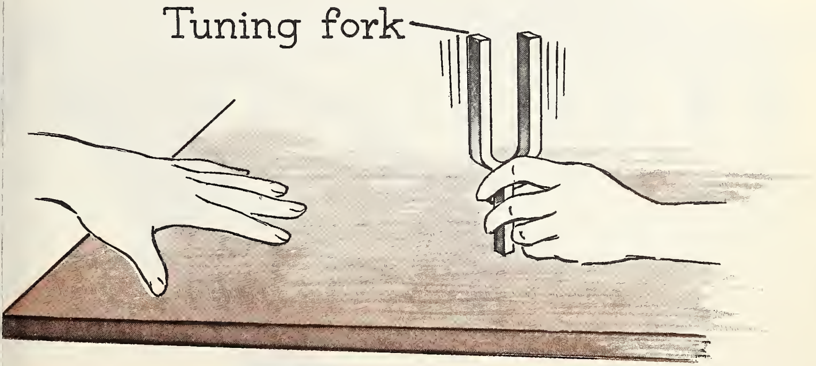
Stretch a wire between two screw eyes in a board. Put a small piece of wood under the wire to tighten it. Now pluck the wire so that it moves rapidly back and forth. Look closely at it to see it vibrate. Put little folds of paper on the wire and watch them. Does the wire give off a sound when it vibrates?



Sometimes you cannot see things vibrate but you can feel them. Rap a tuning fork or a table fork against a piece of wood. Touch the fork lightly to your cheek.

Hold the handle of a vibrating tuning fork against a table top. Touch the table top with your fingers. Can you feel the table vibrating?

Often you can feel a radio or a phonograph vibrating when you touch it with your fingers. When a big pipe organ is played in church, you can sometimes feel the building vibrating.



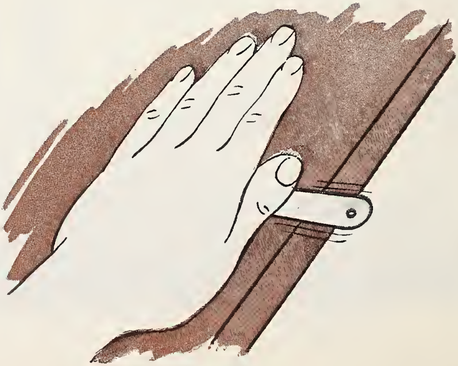
# The Pitch of Sounds

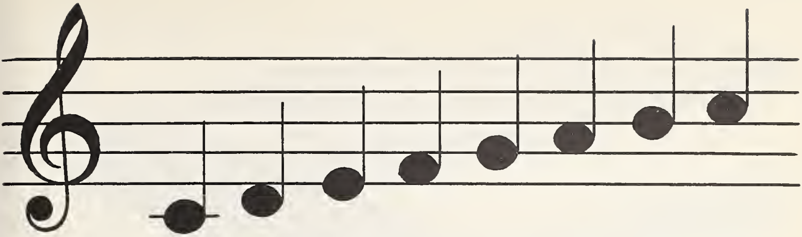
Hold a nail file against a table as you held it before. Make the nail file vibrate and listen to the sound.

Hold the nail file so that a smaller part of it is able to vibrate. Make the nail file vibrate again and listen to the sound.

You will notice that the nail file vibrates more rapidly when the part that vibrates is shorter. You will also notice that the tone changes.

Try the experiment several times. Let different lengths of the file vibrate.



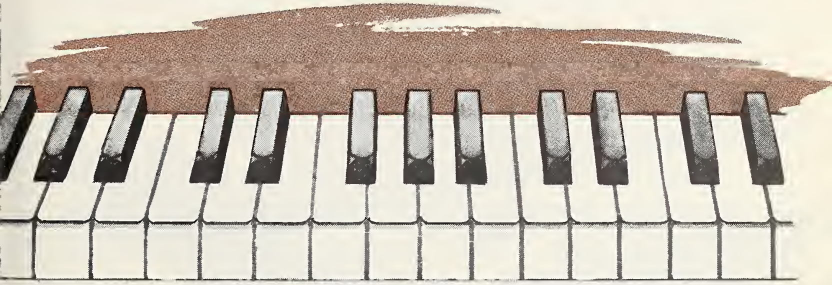


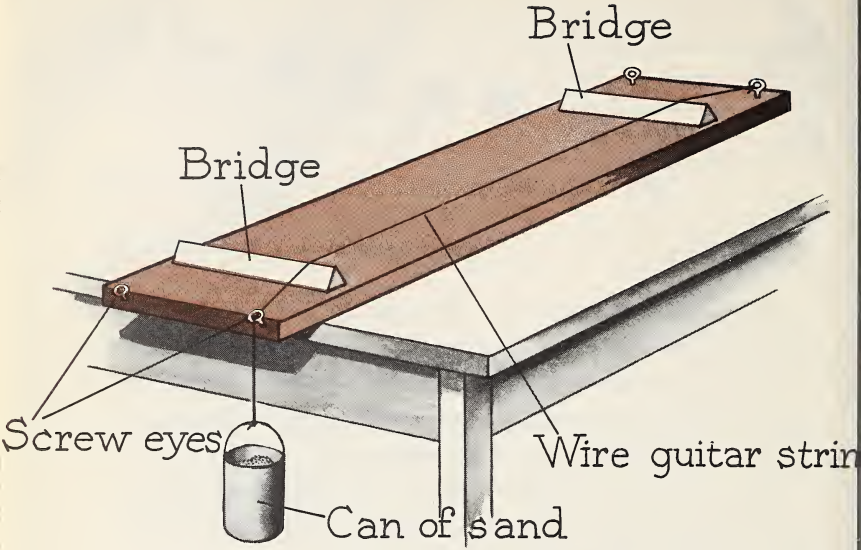
The sound of your voice changes as you sing a scale. You change the **pitch** of your voice.

You raise the pitch of your voice when you sing a scale like the one written above. The last note has a higher pitch than the first note.

You changed the pitch of the sound in the experiment with the nail file. The sound had a higher pitch when the nail file vibrated more rapidly.

The keys of a piano make sounds of different pitch. The keys at the right make sounds of high pitch. The keys at the left make sounds of low pitch.


do re mi fa so la ti do

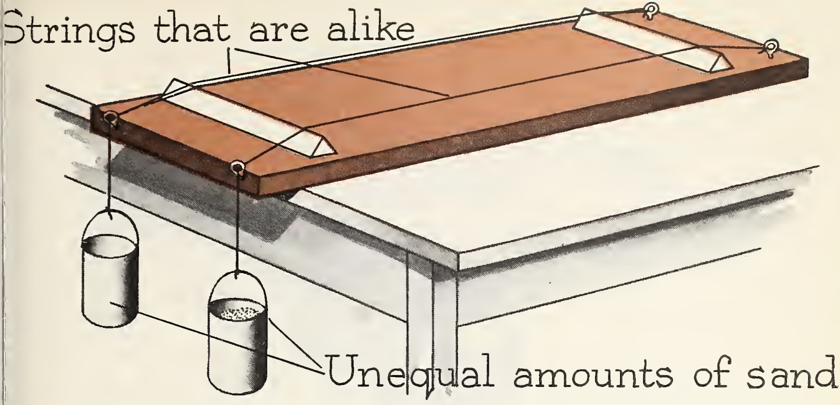


## Vibrating Strings

Some experiments will show you how stringed instruments like violins give off sounds of different pitch. You will need a board, some screw eyes, some guitar strings, and some cans.

Build the apparatus shown in the picture. You can whittle the bridges from small pieces of wood. Fill the can half full of sand.

Pluck the string between the bridges and listen to the sound. Move the bridges closer together and pluck the string again. What happens to the sound as the vibrating part of the string becomes shorter?

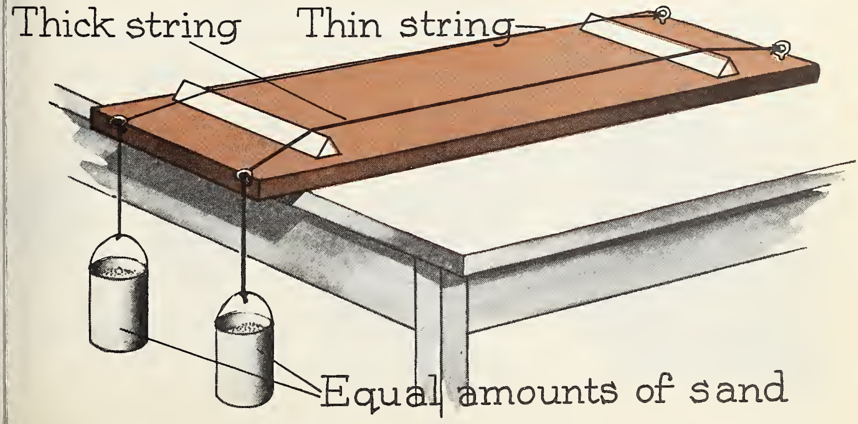


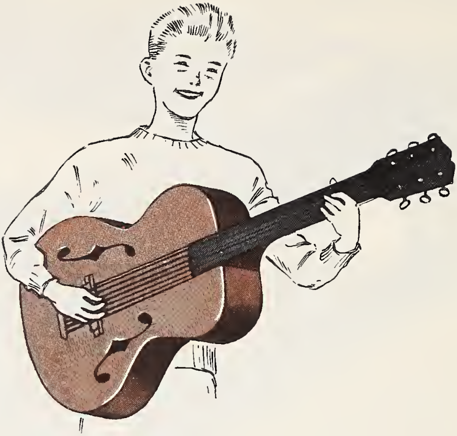
Fasten two strings that are alike on the board. Put more sand in one can than in the other. Which string is tighter? Pluck each string. Which string has the higher pitch?

Add more sand to the cans. What happens to the pitch of the sound as the strings become tighter?

Fasten a thin string and a thick string to the board. Use the same amount of sand in each can so that they are equally tight. Which string has the higher pitch?

You have discovered three ways to change the pitch of vibrating strings. Write down what you have discovered.





## Stringed Instruments

There are three ways of changing the pitch of guitar strings. Thick strings are used for low notes. Thin ones are used for high notes. The player tunes each string by turning a key. He tightens the key to give the string a higher pitch.

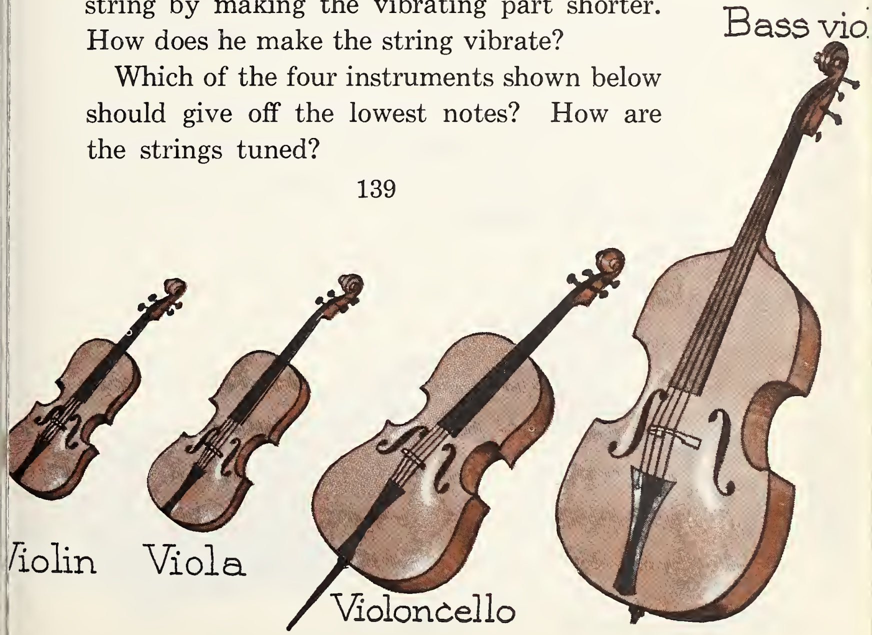
When a player wants to play different notes, he presses the strings to the neck of the guitar. This makes the vibrating part of each string shorter so that it gives off higher notes.

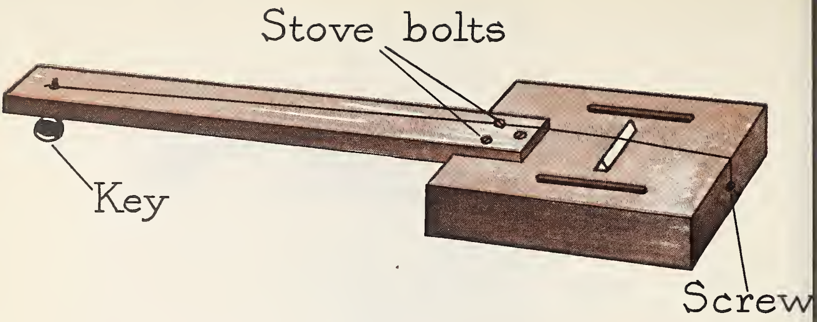
Watch someone playing a guitar. Ask him to show you how he tunes the strings.

Most of the instruments in big orchestras are members of the violin family. Four instruments of the violin family are shown below.

Look at the picture of the boy playing the violin. Notice how he changes the pitch of a string by making the vibrating part shorter. How does he make the string vibrate?

Which of the four instruments shown below should give off the lowest notes? How are the strings tuned?



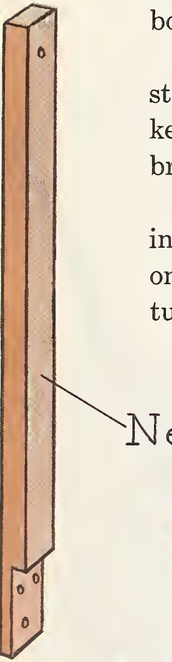


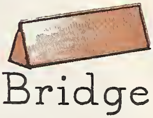
## Homemade Stringed Instruments

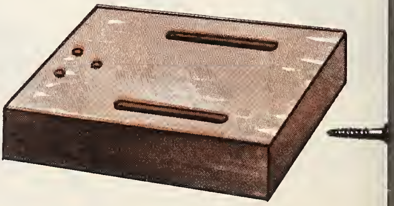
You can make a guitar from a cigar box. Use a jackknife to cut two slots in the bottom of the cigar box. Saw out a board for the neck of the guitar and fasten it to the box with three stove bolts. Then nail the cover shut.

Whittle a key or buy a violin key at a music store. Bore a hole in the neck for the key. The key must fit tightly in the hole. Then whittle a bridge or buy one.

Fasten one end of a wire guitar string to a screw in the end of the cigar box. Wind the other end on the key. Tighten the string and you can play a tune on the guitar.



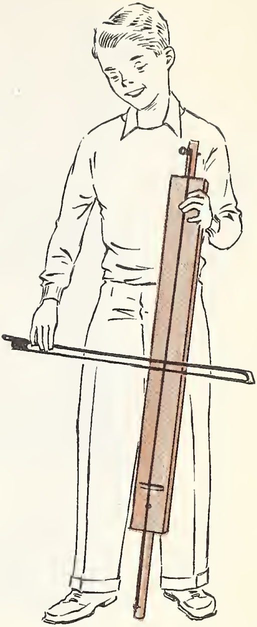


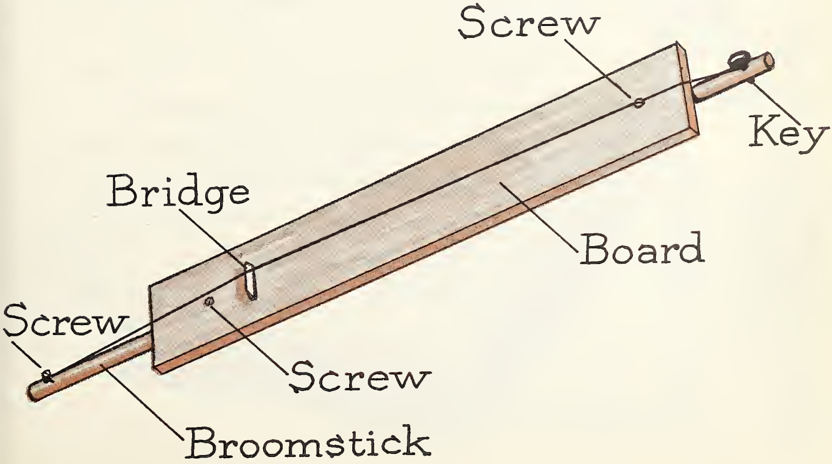


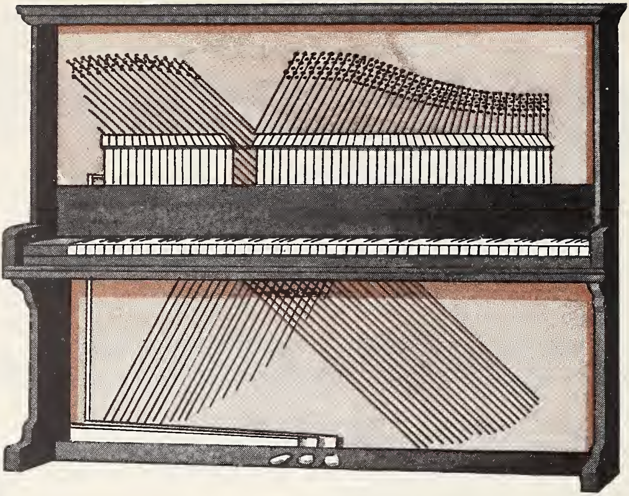
You can also make a violin with a broomstick and a board. You will need a violin bow to play it.

Fasten the board to the broomstick with short screws. Mark the place where the key should go with a small nail hole. This nail hole will make it easier to start boring the hole for the key. Finish your violin as shown in the picture.

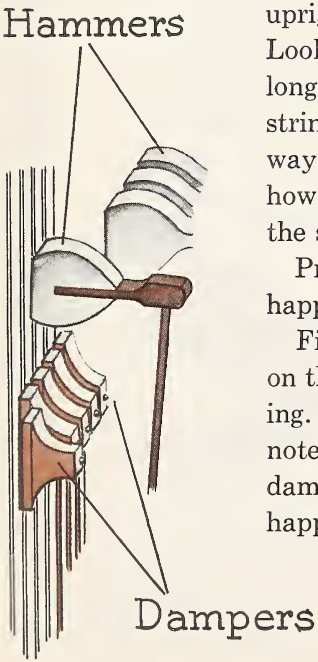
You can play real tunes on this violin. You can make marks on the board so that you will know where to put your fingers for the different notes.







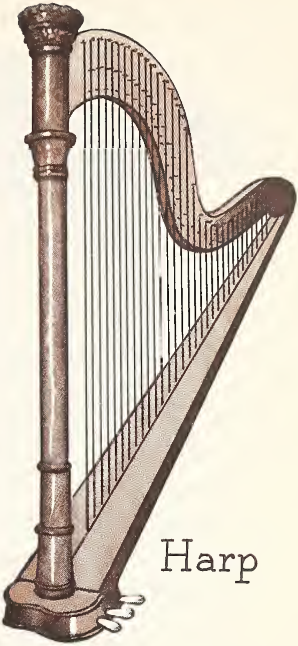
## The Piano



Ask someone to take off the front of an upright piano so that you can study it. Look at the strings. Which strings are longest? Which are thickest? Which strings have the highest pitch? Notice the way the strings are fastened. Can you see how the piano tuner changes the pitch of the strings?

Press a piano key slowly. Notice what happens. What does the hammer do?

Find the dampers. The dampers rest on the strings and keep them from vibrating. Watch a damper when you play a note. What happens? Press on the damper pedal and play some notes. What happens?

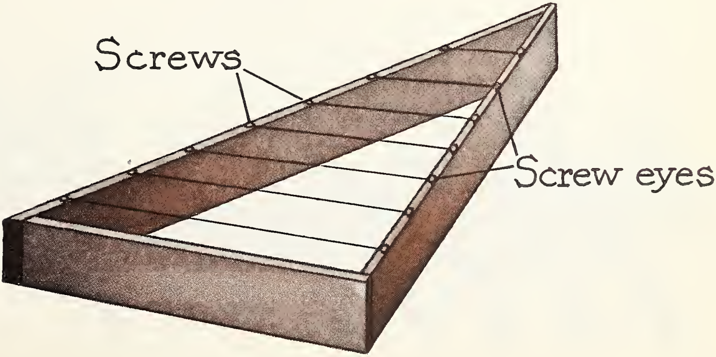


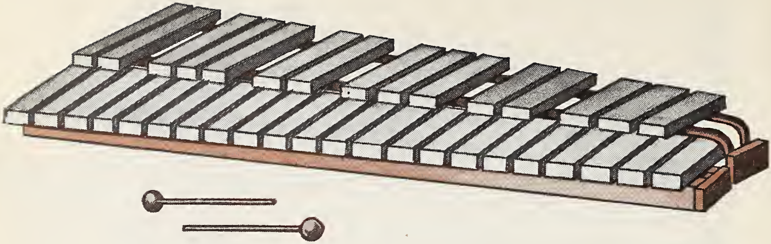
## The Harp

A harp is somewhat like a piano. There are many strings. Some strings are longer and thicker than other strings. Some strings are tighter than others.

The harp is played by plucking the strings. How are the strings of a piano made to vibrate?

You can make a simple harp by nailing three boards together in the shape of a triangle. Fasten one end of each string to a screw on one side of the triangle. Fasten the other end of each string to a screw eye. Tune the strings by turning the screw eyes. Tune the strings to match the notes of a piano. Then you can play tunes on the harp.





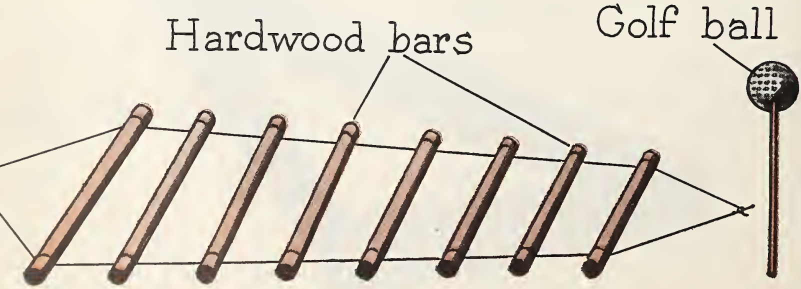
## The Xylophone

The musical notes of a xylophone come from bars of wood. The bars are struck with little hammers to make them vibrate. There are other musical instruments that have bars of metal that vibrate.

You can make a xylophone from pieces of broom handles. Cut eight pieces to the following lengths:

10 inches
$9\frac{7}{16}$ inches
$8\frac{15}{16}$ inches
$8\frac{11}{16}$ inches
$8\frac{3}{16}$ inches
$7\frac{12}{16}$ inches
$7\frac{5}{16}$ inches
$7\frac{1}{16}$ inches

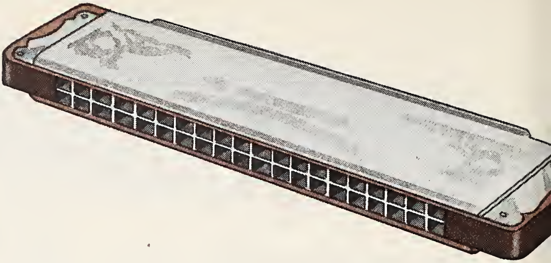
Tie the bars together with two stout strings as shown below. Play them by hitting them with a golf ball on a small stick. You may need to tune the bars. Whittle off the end of a bar to raise the pitch. Whittle a little wood from the middle to lower the pitch.



A set of musical glasses is something like a xylophone. Find some drinking glasses that ring when you tap them with a pencil. Pour a little water into one of the glasses. Does the water raise or lower the pitch of the glass?

Pick up eight glasses and tune them to the notes of the scale by putting water in them. Tap them with a pencil. You can play simple tunes on them.

You may also use bottles instead of drinking glasses. Tune them with water just as you tuned the glasses.

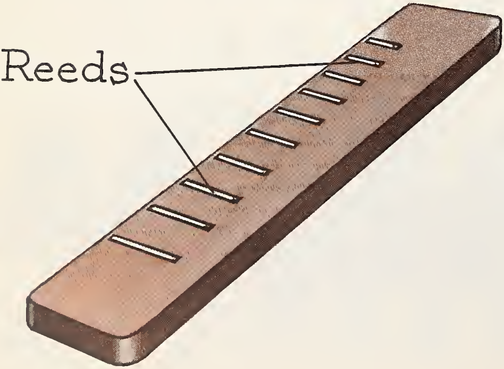


## Reeds

Perhaps you can take a mouth organ apart to see what is inside. Notice the little strips of metal that make the sounds. These strips are called **reeds.**

A reed vibrates when air blows past it. Short reeds give sounds of high pitch. Long reeds give sounds of low pitch.

Reeds are used in accordions. Each key on the accordion opens a valve that lets air blow past a reed. The air comes from the bellows of the accordion. Watch someone play an accordion and notice what he does.

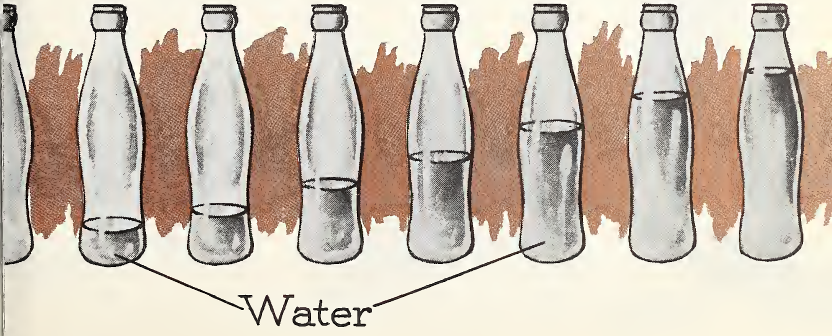


## Vibrating Columns of Air

Blow over the top of a bottle to make a musical sound. Now put a little water in the bottle and blow across its top again. Did the water raise or lower the pitch of the sound?

Scientists tell us that the column of air in the bottle vibrates when you blow across the top of the bottle. The vibrating air gives out the sound. When you put water in the bottle you made the air column shorter and raised its pitch.

Bring eight bottles to school. Tune the bottles by putting water in them so that you can play a musical scale on them.

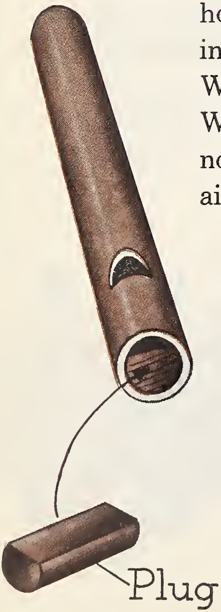


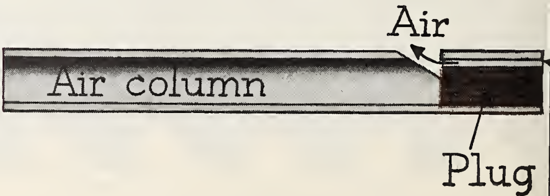
## Whistles

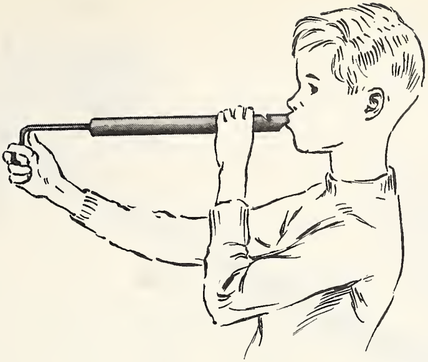
Whistles make sounds in the same way that bottles make sounds when you blow over them. There is an opening in a tube. Air is blown past this opening. This makes the column of air in the whistle vibrate.

Bring different kinds of whistles to school. Find the column of air in each one. Find the opening that you blow past.

You can make a whistle from a piece of hollow wood such as bamboo. Cut a notch in the side of the tube as shown in the picture. Whittle a plug that almost closes the tube. When you blow the whistle, air goes out the notch. As it goes out, it makes the column of air in the tube vibrate.





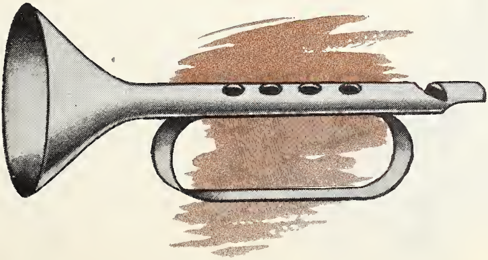


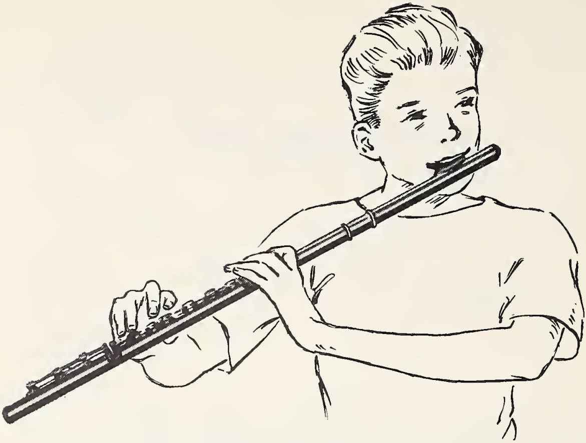
A long whistle has a long column of air. It gives off a low note. A short whistle has a short column of air. It gives off a high note.

You can change the length of the air column in a slide whistle. Pull the slide out to make a low note and push it in to make a high note. You can play tunes on the whistle.

Another whistle has holes along the side. You can cover the holes with your fingers. With all holes covered, the column of air is as long as the whistle. When you uncover a hole, the vibrating column of air becomes shorter.

Bring some whistles like these to school and study them.

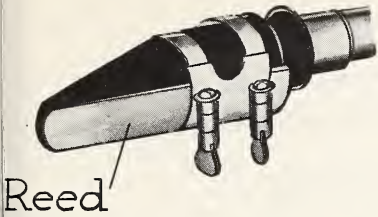




## Wind Instruments

A flute is somewhat like a whistle. The player blows over a hole in the flute just as you blow over a bottle. He changes the pitch of the flute by opening or closing holes in the flute. The pitch of the sound is low when all the holes are covered, because the air column is as long as the flute.

A clarinet has a reed in the mouthpiece. The reed vibrates and makes the column of air in the clarinet vibrate. The player changes the pitch much as a flute player does.

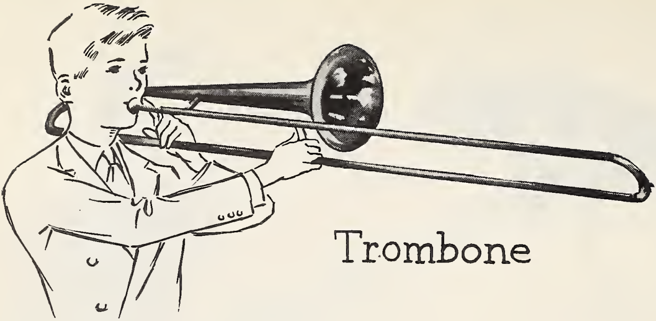


A saxophone is a good instrument for study. Perhaps someone can bring one to school for you to look at.

Notice the reed. The reed vibrates when the player blows on the saxophone. The reed makes the air column in the saxophone vibrate.

Notice the holes in the saxophone. The holes are covered by pressing on keys. Ask someone to play the saxophone and notice how he changes the pitch.

Visit a music store and look at the different sizes of saxophones. Do you think the large saxophones or the small saxophones have the lower pitch?

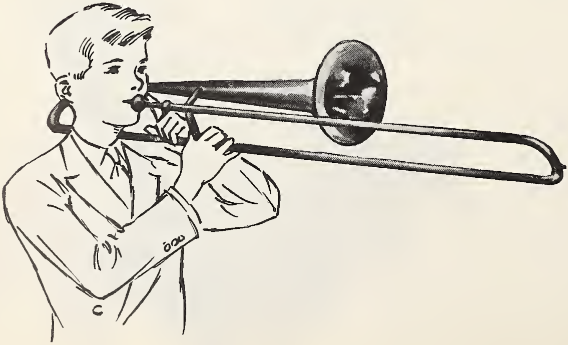


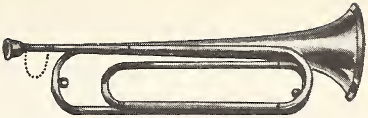
# Trombone

A trombone is another kind of wind instrument. The player makes the air in the trombone vibrate by vibrating his lips. Ask someone to show you how he holds his lips to do this.

A trombone has a long air column which makes low notes. The player can change the pitch by sliding part of the trombone in or out. This makes the air column shorter or longer.

The pictures on this page show how the player changes the pitch. The top picture shows the slide pushed out. The air column is long and a low note is being played. The bottom picture shows the slide pulled in. The air column is short and a higher note is being played.





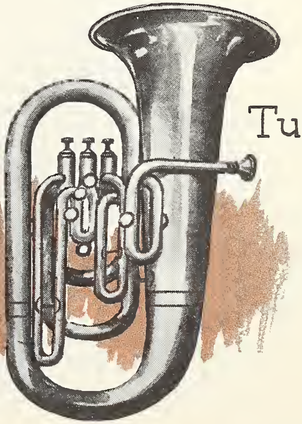
Bugle

Imagine that you could straighten out a bugle. It would look like the one in the picture at the left. The air column would be as long in the straight bugle as in the coiled bugle. What is the advantage of the coiled bugle?

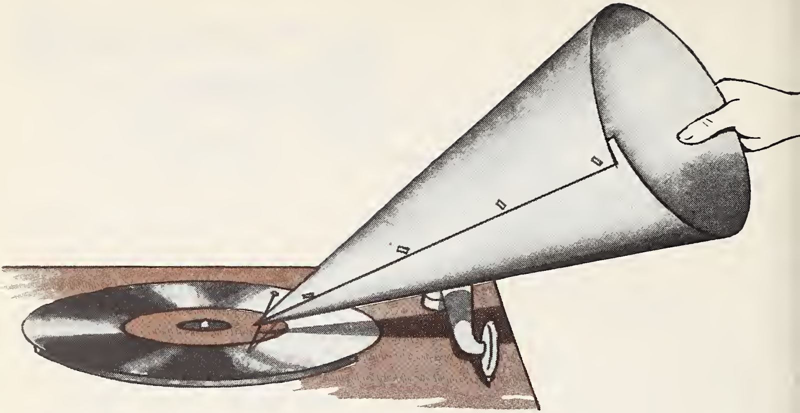
Look at the pictures of other kinds of horns. Imagine that each one could be straightened out. Guess how long each one would be.

Use a string to measure the air column in a horn. Hold one end of the string at the mouthpiece. Lay the string along the horn so that it follows every curve. Cut off the string at the large end of the horn. Now straighten out the string and see how long it is.

French horn



Tuba



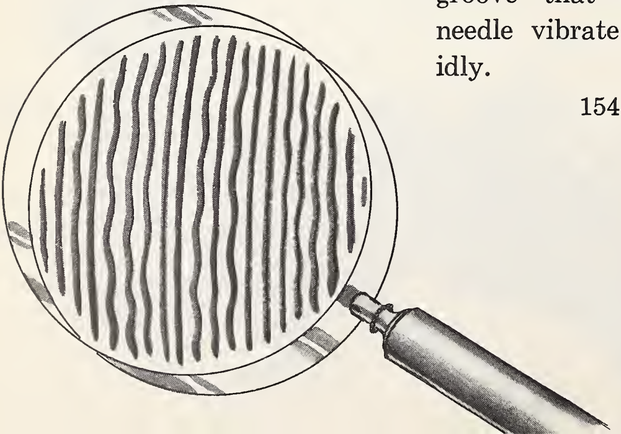
## Storing Sounds

This experiment will help you understand how sounds are stored on a phonograph record.

Make a horn of light cardboard. Push a needle or a pin through the small end of the horn. Rest the needle on a phonograph record that is turning around. What happens?

Look at a phonograph record with a hand lens. Notice the grooves. The waves in the grooves make the needle vibrate. This causes the sound.

In the picture find the groove that makes the needle vibrate most rapidly.

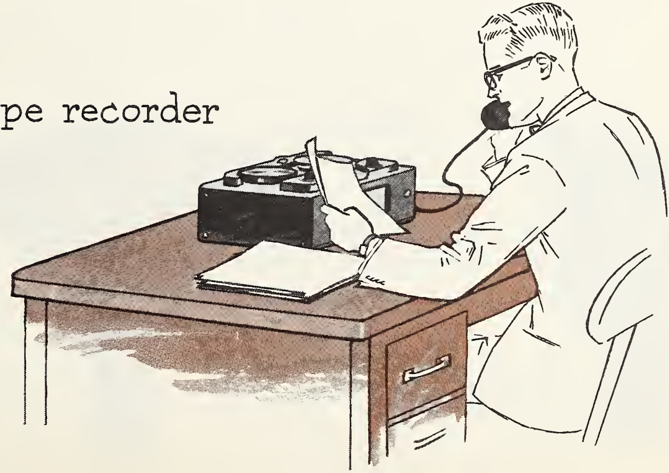


You can see record-making machines in radio stations. Some people also have them to make records for their own use.

A record-making machine has a needle that cuts a groove in a record. The needle vibrates rapidly when there is a high-pitched sound. Then the groove has many waves close together. The needle vibrates more slowly for low-pitched sounds. Then the waves are farther apart. The groove is straight when there is no sound.

The records you buy are moulded from master records made in this way. Several thousand records may be moulded from one master record.

There are other kinds of machines used for storing sounds. Some store sounds in wire and others in tape. You must know more about electricity and magnetism to understand how they work. You can see these machines in radio stations, in some homes, and in business offices. Find out how they are used.



Tape recorder

## The Voice Box

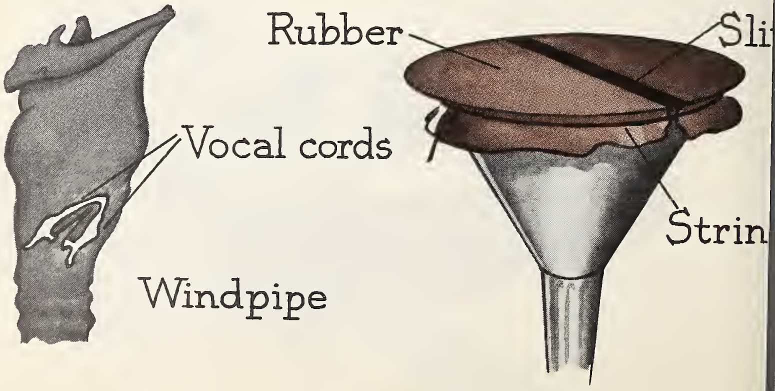
Press your fingers to your throat and find a tube that seems to be made up of hard rings. This is your windpipe.

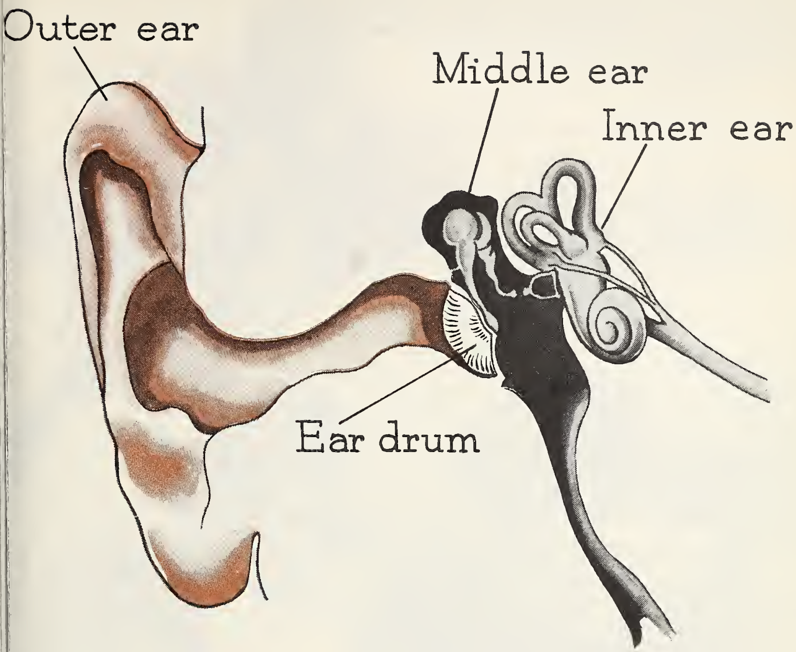
Find the hard bump that seems to move when you swallow. This is your voice box. It is at the top of the windpipe.

There are two cords stretched across the voice box. They vibrate when you blow air past them. Put your fingers on your voice box as you hum. Notice the vibrations.

You tighten the cords to make sounds of high pitch. You loosen the cords to make sounds of low pitch.

Make a model voice box with a funnel and two pieces of rubber from a balloon. Tie the pieces on the funnel so that there is a narrow slit between them. Blow through the funnel.



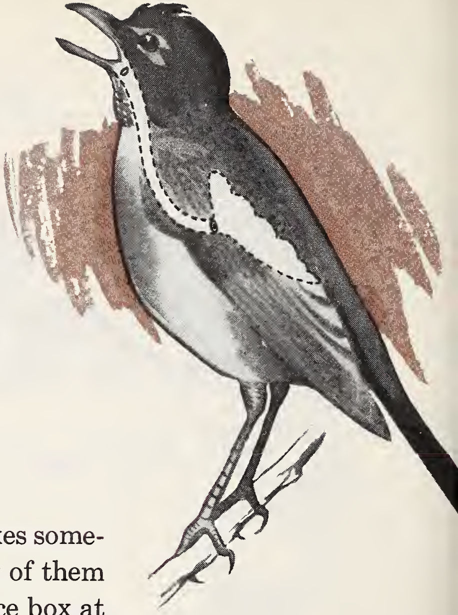


## Our Ears

Most of the sounds you hear come through the air. These sounds are brought to you by vibrating air.

Vibrating air makes your ear drums vibrate. This makes some tiny bones in your middle ears vibrate. The bones in their turn make your inner ears vibrate.

Nerves in the inner ears send messages to your brain telling whether your ears are vibrating rapidly or slowly. From the messages, you know whether you are listening to a high-pitched sound or a low-pitched sound.



## Bird Voices

Birds have voice boxes somewhat like ours. Many of them also have a second voice box at the bottom of the windpipe.

Such birds use the second voice box for most of their singing. Birds make some of their call notes and alarm notes with the upper voice box.

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1. What causes sound?
2. How can you change the pitch of a vibrating string?
3. Which bars of a xylophone have the highest pitch?
4. How do you make sounds when you speak or sing?
5. If you add water to a bottle what happens to the pitch of the sound you make when you blow over it?
6. How do most sounds come to your ears?
7. How is the pitch of a flute changed?

# Some Common Acids

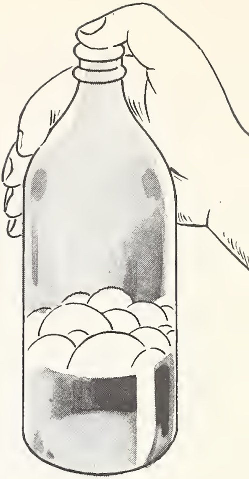
## Vinegar and Baking Soda

Fill a glass nearly full of water and dissolve a teaspoonful of baking soda in it. Add a little vinegar and stir it. What do you see in the liquid?

Put a teaspoonful of baking soda in a glass. Pour in some vinegar. What happens? Try the experiment again. Does the same thing happen?

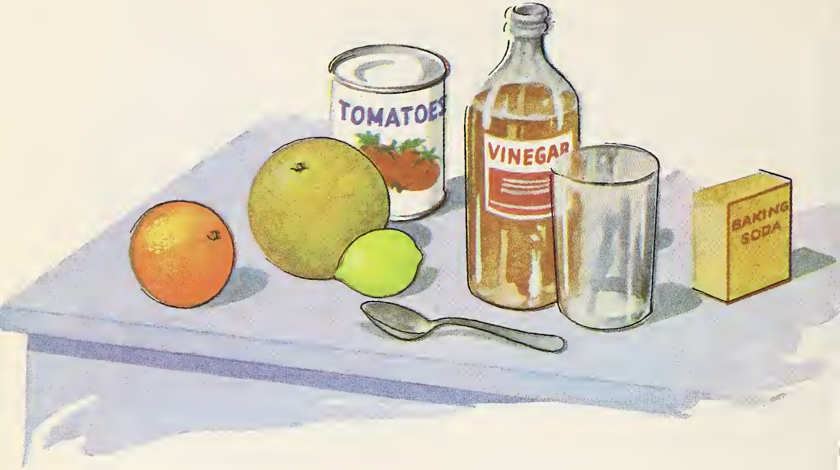
Light a match and hold it in the glass. What happens to the flame? Try this several times. Does the same thing happen each time?

The bubbles that you see in the mixture of vinegar and baking soda are bubbles of a gas called carbon dioxide.



Put some vinegar and baking soda in a bottle. Hold your thumb over the mouth of the bottle. Notice how the gas pushes your thumb. It may even push your thumb away from the mouth of the bottle.

Take the bottle outdoors. Put the bottle in a can. Pour in a few tablespoonfuls of vinegar and the same amount of water. Then put in a teaspoonful of baking soda. Put a cork in the bottle and stand back. What happens?



## Acids in Foods

There are many liquids that give off bubbles of carbon dioxide when baking soda is mixed with them. Try lemon juice, orange juice, grapefruit juice, and tomato juice. Try some other foods when you go home.

Taste the different foods that bubble when they are mixed with baking soda. Most of the foods will taste sour.

Most things that are sour and that give off bubbles when mixed with baking soda are called **acids.** There are acids in many of our foods. Do you know of any other acids?

## Dry Acids

Your mother may use a chemical called cream of tartar when she bakes. Taste a bit of this chemical. How does it taste?

Mix a teaspoonful of cream of tartar with a teaspoonful of baking soda. What happens? Add half a cup of water. What happens?

This experiment shows that water must be added before cream of tartar and baking soda will give off carbon dioxide. Water is often needed when chemicals are used together.

There are other dry acids besides cream of tartar. Boric acid is a common dry acid.

## Baking Powder

Most cooks use baking powder. Look in a cookbook for some foods that have baking powder in them.

The label on the can tells what is in baking powder. Collect the labels from cans of different kinds of baking powder.

There is baking soda in all baking powders. Sometimes the baking soda is called bicarbonate of soda. There is also a dry acid in all baking powders. Sometimes the acid is cream of tartar.

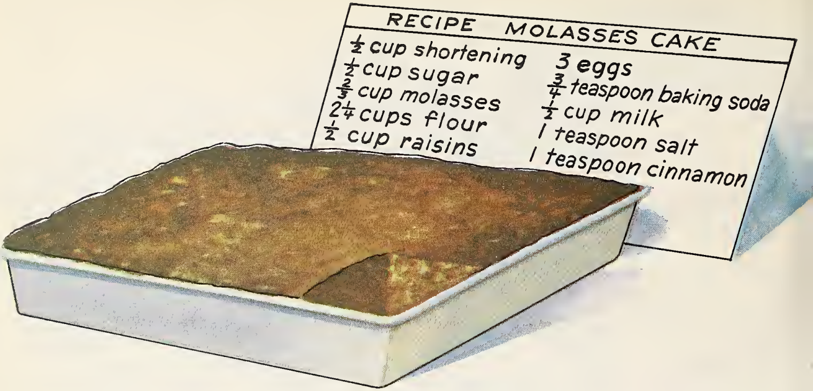
Put a teaspoonful of baking powder in a glass of water. What happens?

For this next experiment it is best to use a baking powder that is made with cream of tartar.

Mix a teaspoonful of the baking powder with half a glass of flour. Add just enough water to moisten the flour. Mix the flour and water rapidly. Then watch the mixture through the glass.

Baking powder makes bubbles of carbon dioxide in the dough. The bubbles make the dough rise. Look at cake and biscuits for holes left by bubbles of gas.

Make some biscuits with baking powder. At the same time make some biscuits without baking powder. How are they different?



RECIPE MOLASSES CAKE

½ cup shortening
½ cup sugar
⅔ cup molasses
2¼ cups flour
½ cup raisins

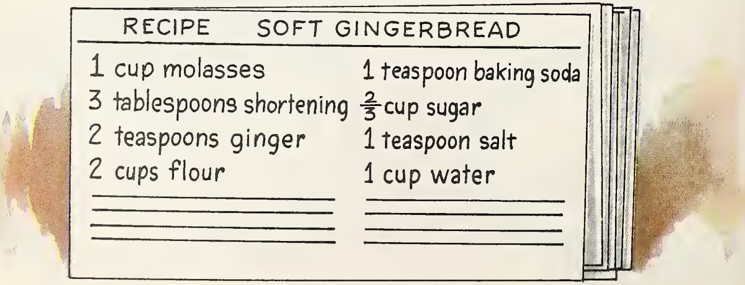
3 eggs
¾ teaspoon baking soda
½ cup milk
1 teaspoon salt
1 teaspoon cinnamon

## Baking Without Baking Powder

This cake has no baking powder in it, but it rises like other cakes. The recipe shows that there is baking soda in the cake. There must also be an acid in the recipe.

Test each of the things in the recipe to find the acid. Test them with baking soda just as you tested lemon juice and cream of tartar. You should find some acid in the molasses.

Look at recipes for cakes, cookies, and biscuits. Find recipes that call for baking soda. Then test the things in these recipes to find out whether any of them contain acids.



RECIPE SOFT GINGERBREAD

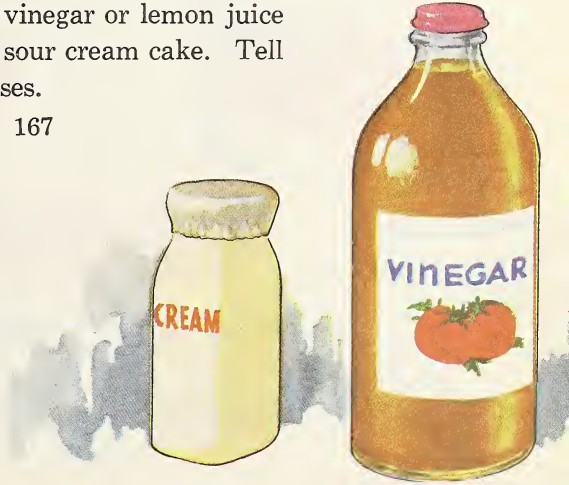
1 cup molasses
3 tablespoons shortening
2 teaspoons ginger
2 cups flour

1 teaspoon baking soda
⅔ cup sugar
1 teaspoon salt
1 cup water

This is another cake that does not use baking powder. Does the name of the cake tell you where the acid is?

Try to get some sour milk or sour cream. Test it with baking soda. Is there an acid in it? Buttermilk is left after the butter is taken from sour cream. Test some buttermilk to see if there is an acid in it.

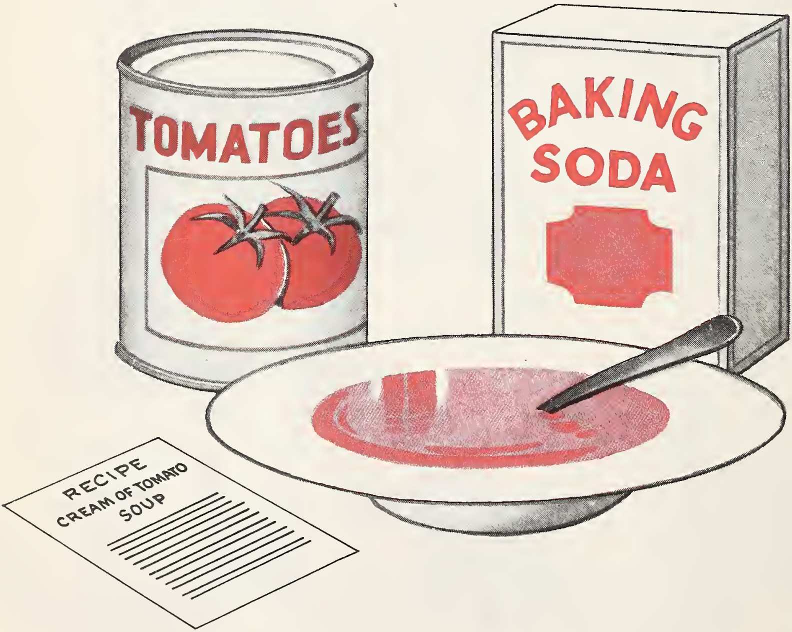
When cooks do not have sour cream, they sometimes use fresh cream. Then they add a little vinegar or lemon juice in the recipe for sour cream cake. Tell why the cake rises.

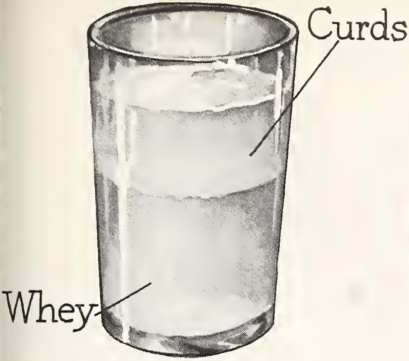


## Acids and Milk

Put a drop of vinegar or lemon juice in a spoonful of milk. What happens? Perhaps you have seen the same thing happen when you put cream on strawberries. Acids make milk curdle.

Cream of tomato soup is made with tomatoes and milk. The acid in the tomatoes curdles the milk. Some people do not like to see curdled milk in soup, so cooks often put a little baking soda in the tomatoes before the milk is added. The acid unites with the soda instead of curdling the milk.





Sour skim milk

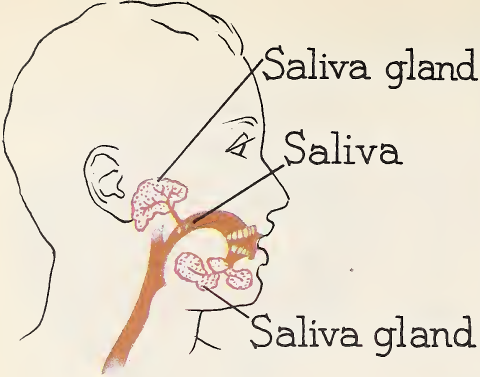
Sour milk cheese

You have seen that there is an acid in sour milk. This acid curdles the milk. That is why sour milk is always curdled.

Thick, white curds rise to the top of sour milk after it has been standing for a while. The curds may be skimmed off and made into cheese. For thousands of years, cheese has been made from the curds of sour milk.

The acid in sour milk comes from certain bacteria that live in milk. These bacteria are not harmful, but there may be other bacteria that are harmful living with them. Milk is pasteurized to kill these harmful bacteria. Pasteurized milk is safe to drink.

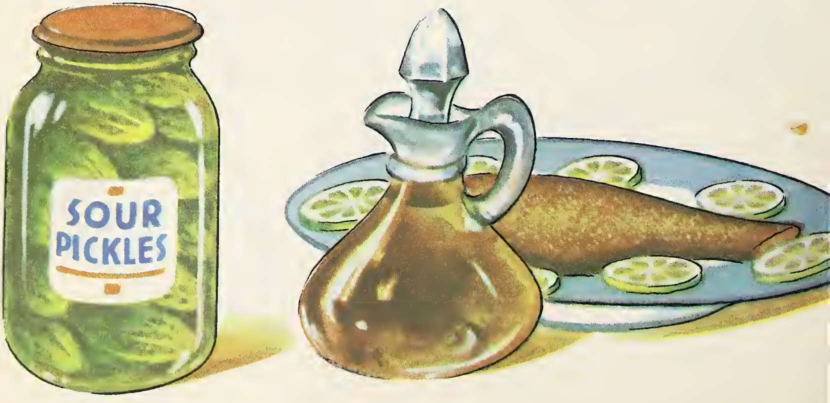
Sour milk bacteria

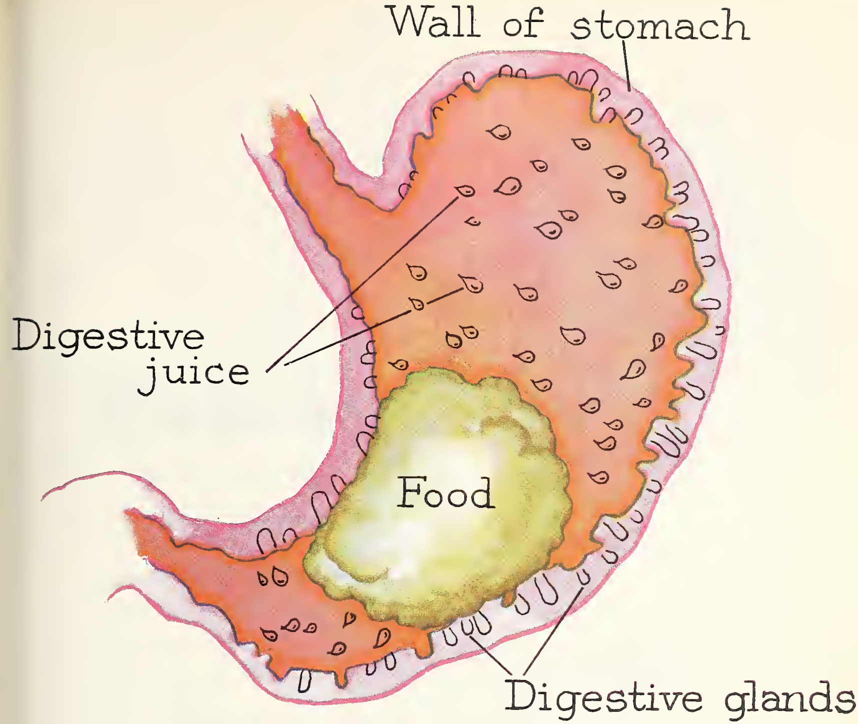


## Acids and Digestion

At your next meal eat a bit of pickle before you eat anything else. Notice how fast the saliva comes from your saliva glands. Perhaps it is flowing rapidly right now as you think about pickles.

Foods with acids in them often make saliva flow faster, and the foods become easier to swallow. Vinegar is used in pickles and salad dressing. It is put on such foods as beans and greens. Lemon juice is put on fish. Some people like to start a meal with a small glass of tomato juice.





There are many glands in the walls of the stomach. These glands give off a digestive juice. There is an acid in the digestive juice.

This acid is important. It starts the muscles of the stomach working. It helps other chemicals in the digestive juice dissolve certain kinds of food. It starts other glands working to give out digestive juices.

The acid in the stomach also kills many bacteria in our food. This keeps the food from spoiling when it is in our stomachs. Unluckily for us, there are some disease bacteria that this acid cannot kill.

Teeth injured by sucking lemons

## Harmful Acids

Strong acids in food may dissolve some of the enamel from our teeth. We cannot grow new enamel, so we should be careful about eating too many of these foods.

It is not wise to suck lemons. Lemon juice can dissolve the enamel. Many people have harmed their teeth by doing this. Mix the lemon juice with water before drinking it.

There are some drinks that are made with phosphoric acid. Scientists have learned that this acid can dissolve the enamel from teeth.

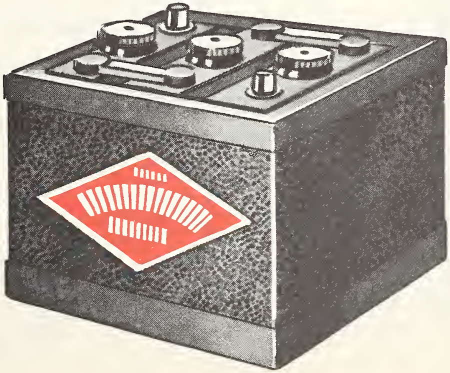
Some dangerous acids

The acids we have been studying are rather weak acids. They are harmless or nearly so. There are other acids that are dangerous. They can burn your skin and harm your eyes. They are deadly poison if you drink them. They can make holes in cloth and dissolve metals.

A dangerous acid is used in the storage battery of an automobile. This acid is sulphuric acid.

Always be careful with acids. Never experiment with them unless you know that they are safe.

Storage battery

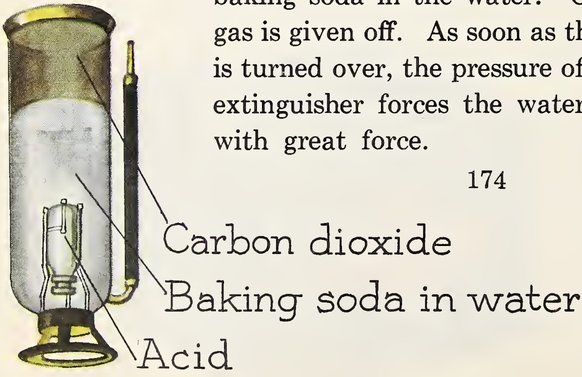


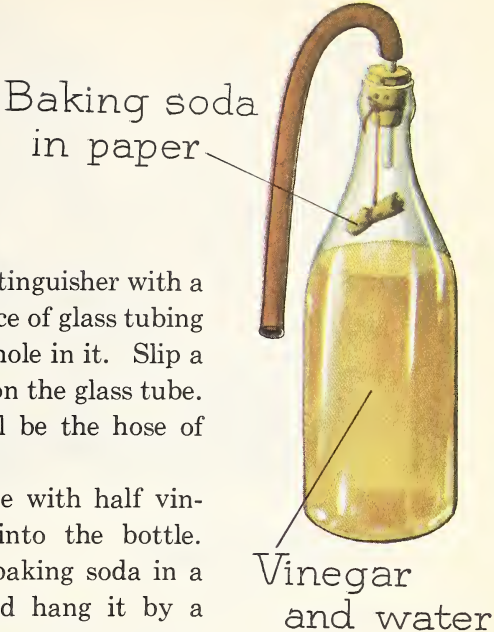
## The Soda-Acid Fire Extinguisher

The soda-acid fire extinguisher must be turned upside down before it is used.

There is water with baking soda dissolved in it. There is also a bottle of sulphuric acid inside the extinguisher.

When the extinguisher is turned over, the acid runs from the bottle and mixes with the baking soda in the water. Carbon dioxide gas is given off. As soon as the extinguisher is turned over, the pressure of the gas in the extinguisher forces the water out the hose with great force.

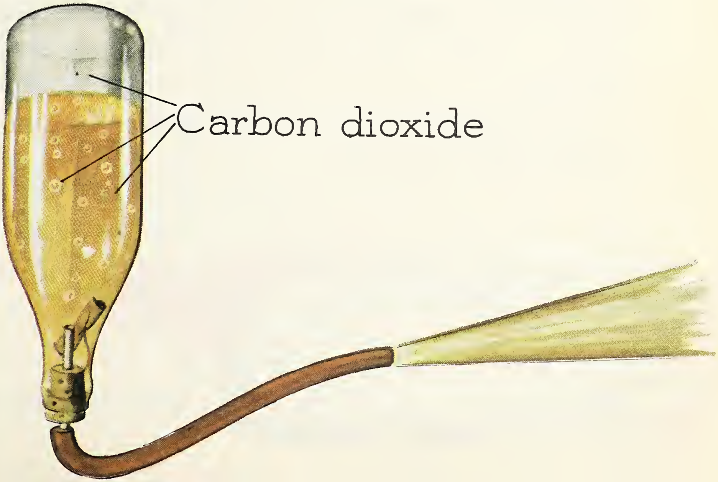


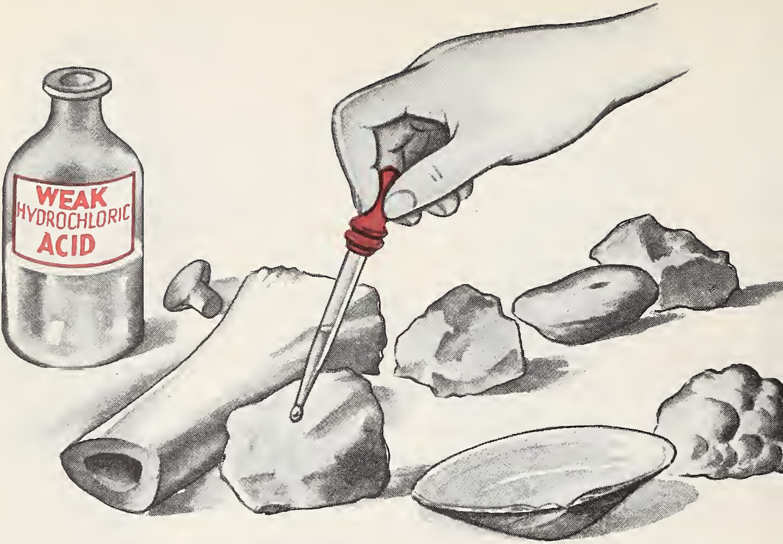


Make a model fire extinguisher with a bottle. Put a short piece of glass tubing in a cork that has one hole in it. Slip a piece of rubber tubing on the glass tube. The rubber tubing will be the hose of the extinguisher.

Pour a mixture made with half vinegar and half water into the bottle. Roll a teaspoonful of baking soda in a bit of tissue paper and hang it by a thread above the liquid in the bottle.

Go outdoors and turn the bottle upside down. Point the tube at a piece of burning paper.





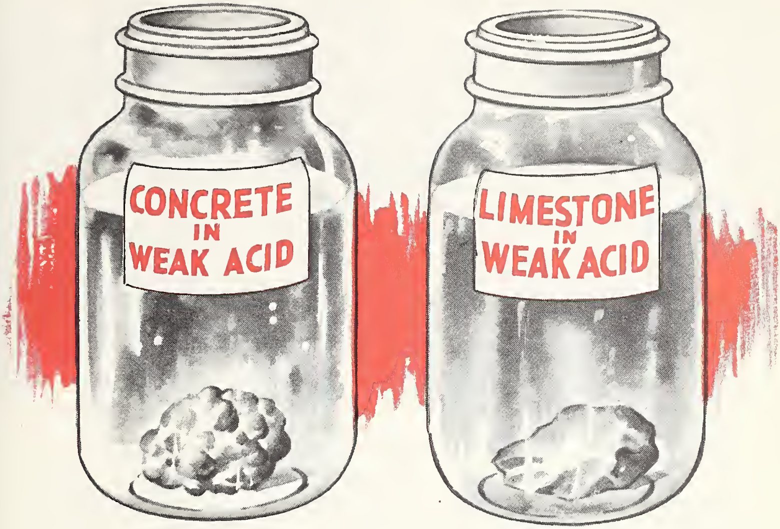
## Acid and Rocks

Weak hydrochloric acid can be used to test rocks for limestone. If the rock makes the acid bubble, it is usually limestone.

Put drops of weak hydrochloric acid on different rocks. Which ones are limestone?

Put drops of the acid on shells and bones. Do they bubble too? Limestone is usually made up of bits of shells. You can often see the remains of the shells in limestone.

Test a piece of concrete. The cement in the concrete is made from limestone.



Put a small piece of limestone or concrete in a small jar of weak acid. What happens to the limestone? What happens to the concrete?

There are often weak acids in streams. What do you think happens when such a stream flows over limestone for many years?

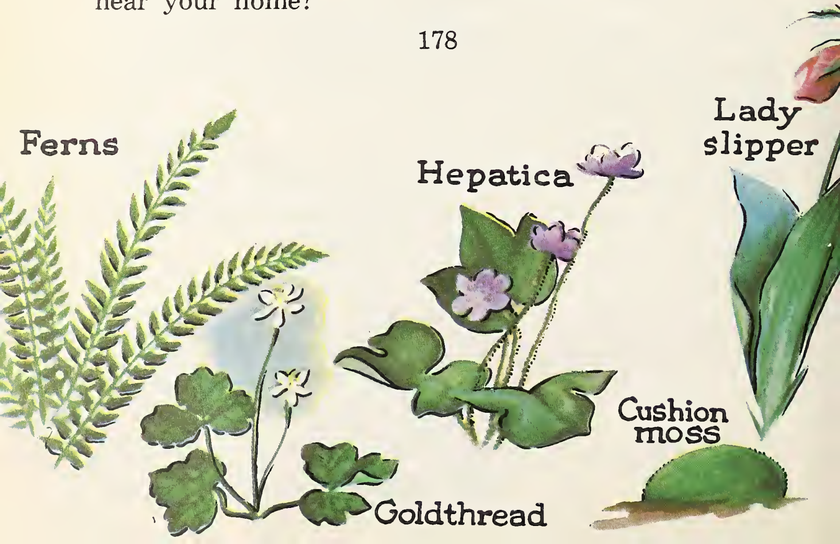
Rain also has a little weak acid in it. Look at some marble monuments that have been standing for many years. Do you see any signs that make you think the acid has been changing the marble?

Plants give off weak acids from their roots. The acids help break down pieces of limestone in the soil. Thus the plants help change rocks into soil.

## Acids in Soil

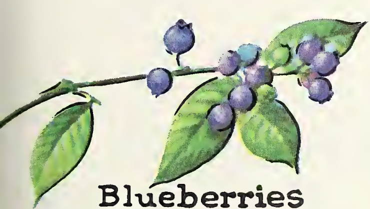
Acid soil is common in deep woods. The plants give off acids as they grow. The decaying plants also give off acids.

Many plants grow best in acid soil. In deep woods you will find ferns, mosses, and some flowering plants that need acid soil. What plants live in the woods near your home?



Very wet places with acid soils are called bogs. Cranberries and blueberries are common in bogs. There is peat moss in most bogs. Sometimes you will also find the interesting plants that catch insects.

Cotton grass



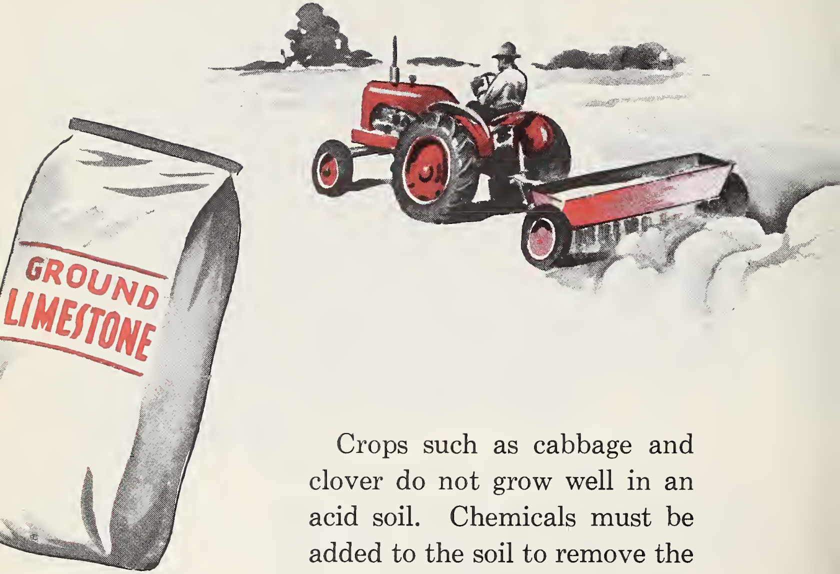
Blueberries

Cranberries

Pitcher plant

Pogonia

Peat moss

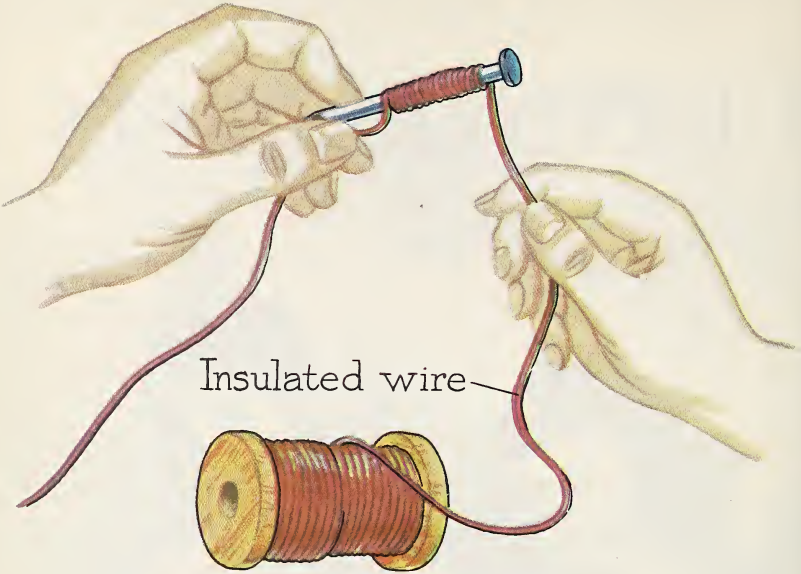


Crops such as cabbage and clover do not grow well in an acid soil. Chemicals must be added to the soil to remove the acids. Farmers usually use lime or ground limestone to remove the acids from their fields.

---

1. Name some foods that have acid in them?
2. What gas is given off when baking soda is mixed with an acid?
3. Why is baking powder put in biscuit dough?
4. What do weak acids do to limestone?
5. Why does milk sometimes taste sour?
6. Why is a soda-acid fire extinguisher turned upside down before it is used?

# Electromagnets

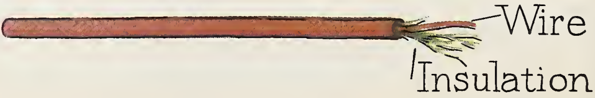


## Making an Electromagnet

A coil of wire becomes an electromagnet when electricity flows through the wire. The electromagnet is stronger if the wire is wound on something made of iron.

Make an electromagnet by winding insulated wire on a large nail. Twenty turns of wire will make a good magnet.

Insulated wire is wire with a covering on it. The covering may be cotton, or rubber, or anything that does not carry electricity well. Why should you use insulated wire on your electromagnet?

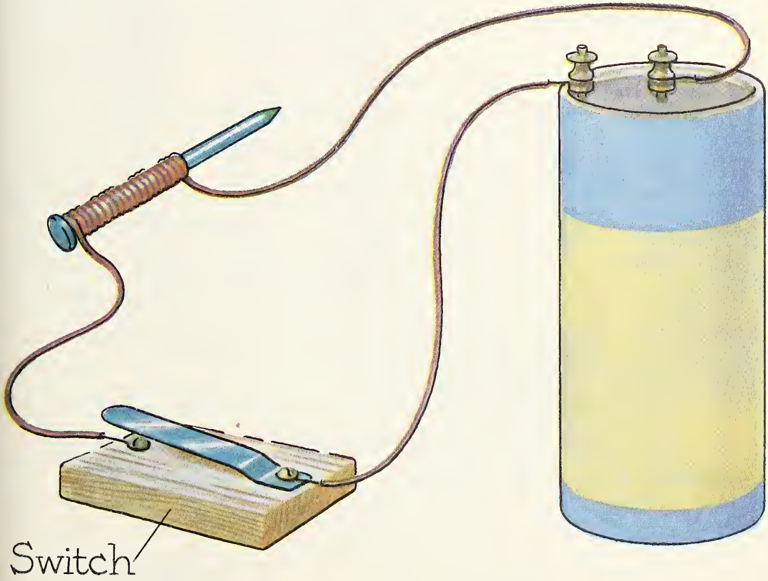


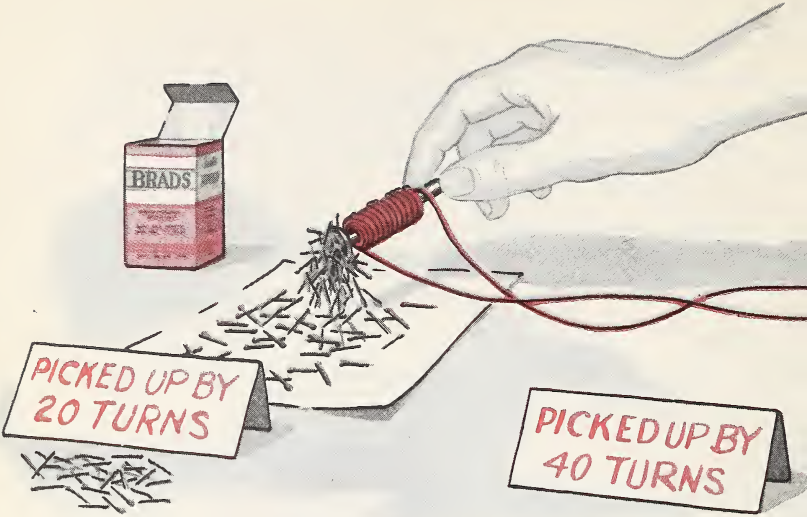
It is well to use a switch when you connect the electromagnet to a dry cell. A dry cell lasts longer if electricity flows only when you need it. The best kind of switch is one that stops the electricity as soon as you take away your hand.

Hold the electromagnet near a pile of small nails. Press the switch. The electromagnet will pick up some of the nails. What happens when you stop the electric current?

Turn the electromagnet around. Can you pick up nails with the other end of it?

Try to pick up pieces of copper, wood, rubber, and other things not made of iron. Will the electromagnet pick them up?





## Experiments with an Electromagnet

Wind twenty turns of insulated wire on a large nail. Connect the wire to a dry cell and a switch. Find out how many small nails the electromagnet can pick up.

Wind forty turns of the same kind of wire on the nail. How many small nails will the electromagnet pick up now?

Some of you may want to try sixty turns of wire on the nail. How many nails can the electromagnet pick up with this number of turns?

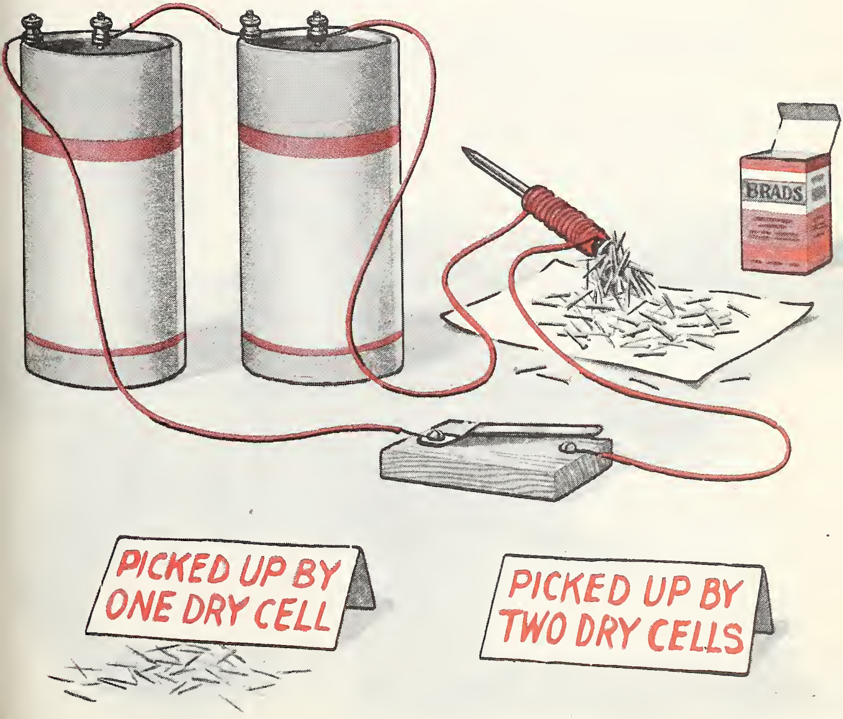
When you add more turns of wire to an electromagnet, is the electromagnet stronger than it was, is it the same, or is it weaker?

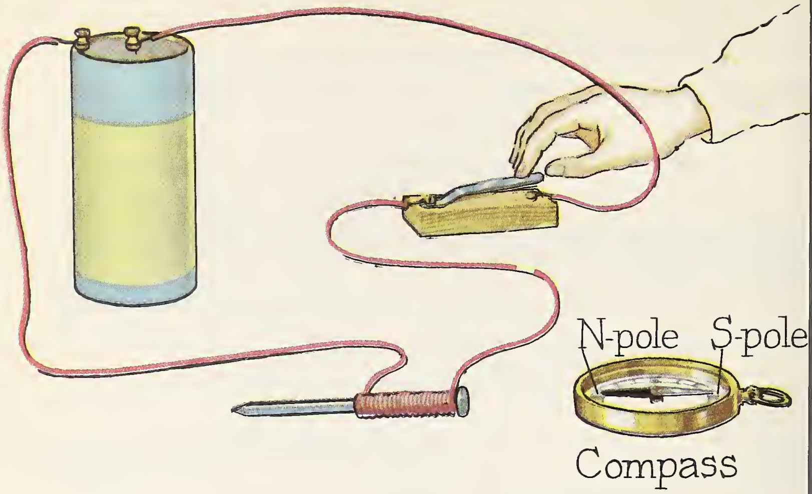
Connect your electromagnet to one dry cell. Find out how many small nails the electromagnet can pick up.

Connect the electromagnet to two dry cells as shown in the picture. Two dry cells force more electricity through the wire. How many small nails can it pick up now?

Is the electromagnet stronger or weaker when more electricity flows through it?

Write down what you have discovered about your electromagnet.


BRADS
PICKED UP BY ONE DRY CELL
PICKED UP BY TWO DRY CELLS

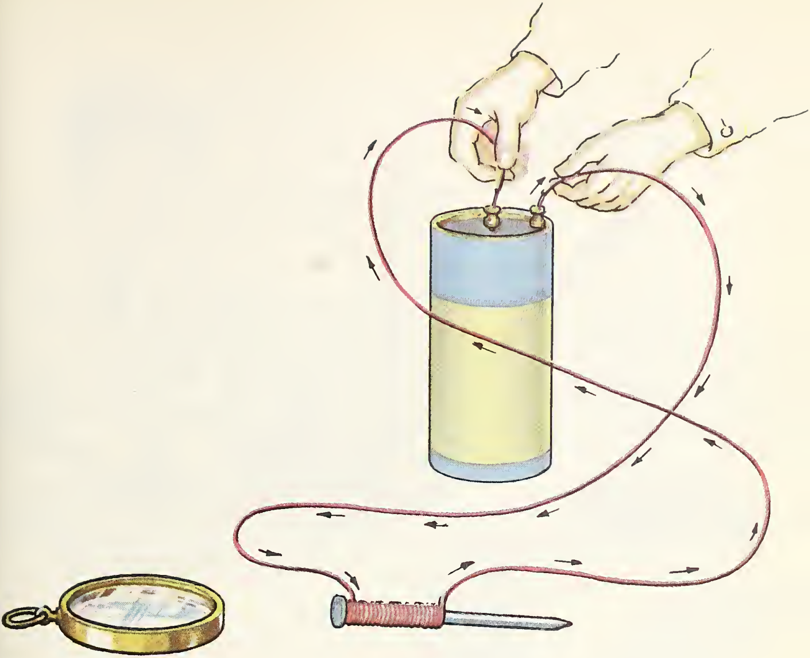


## The Poles of an Electromagnet

Lay an electromagnet on the table. Place a compass about an inch from the head of the nail. Press on the switch to make the electricity flow. Does the N-pole or the S-pole of the compass turn toward the head of the nail?

If the N-pole of the compass turns toward the head of the nail, the head of the nail is an S-pole. If the S-pole of the compass turns toward the head of the nail, the head of the nail is an N-pole. What pole is the head of the nail of your electromagnet?

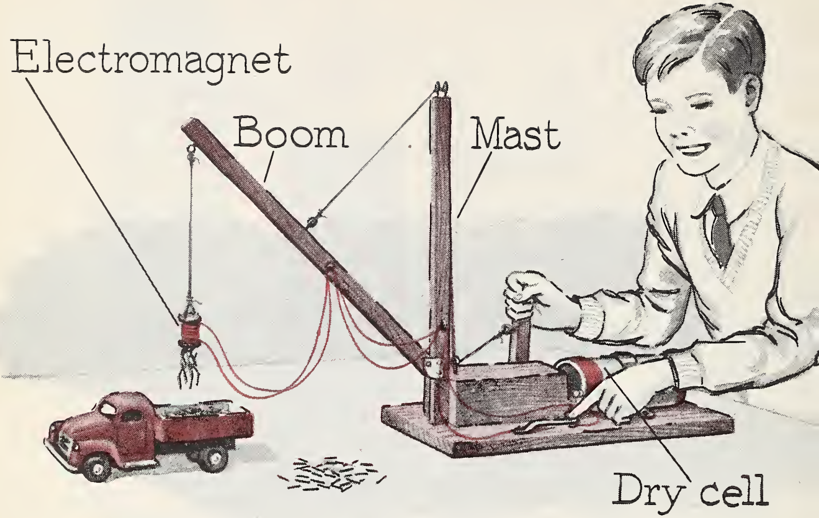
Place the compass about an inch from the point of the nail. Press the switch. Which pole of the compass turns toward the point of the nail? What pole is the point of the nail?



This experiment shows what happens when you change the direction in which the electricity flows.

Place a compass about an inch from one end of an electromagnet. Touch the wires to the binding posts of a dry cell. Notice which way the compass points. Mark the poles of the electromagnet.

Now change the wires so that each touches the other binding post. This makes the electricity flow in the other direction. Notice the compass. Which way is it pointing? What has happened to the poles of the electromagnet?



## Making an Electromagnetic Crane

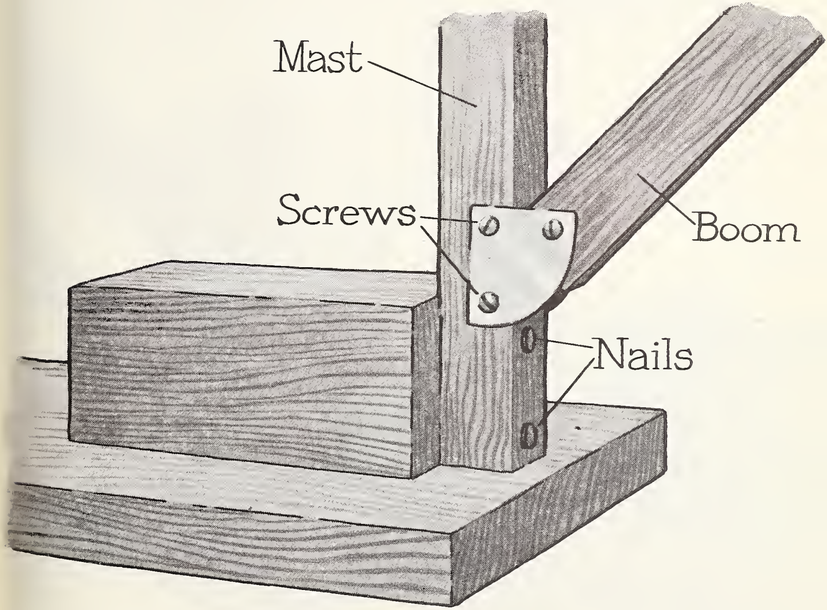
The next few pages tell you how to make a model electromagnetic crane. This crane picks up small things made of iron, moves them to a new place, and drops them. It is like the big electromagnetic cranes that are used to load and unload steel.

You will need a board for the bottom of the crane, a block of wood, and some long, thin pieces of wood. You will need a dry cell and some insulated wire. Most of the other parts are easy to find.

Nail the block in the centre of the board. Use one of the long, thin pieces of wood for the mast. Nail it to the end of the block and drive another nail up through the bottom board into the mast.

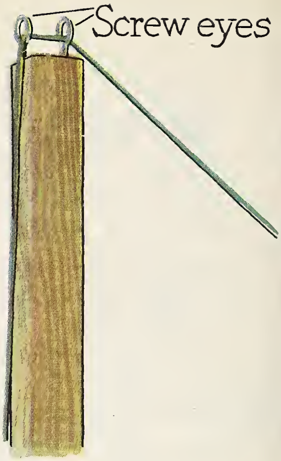
Cut two pieces of metal from a tin can and shape them like the ones in the picture. Punch three holes in each one. Fasten each to the mast with two screws.

The second long piece of wood will be the boom. Fasten it to the pieces of metal with screws. The pieces of metal act as a hinge for the boom. You may use a real hinge here if you wish.

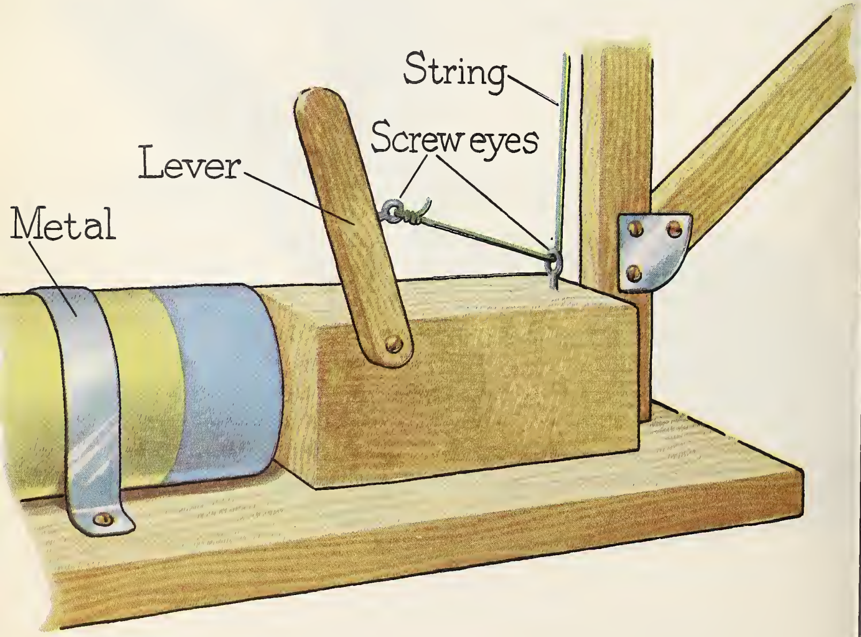


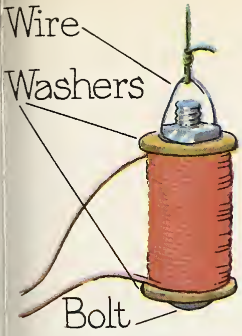
The picture below shows the right hand side of the crane. Notice the lever. It is made of wood and is screwed to the block. It raises and lowers the boom.

A string goes through screw eyes from the lever over the top of the mast to the boom. Study the pictures carefully to find out where to put the screw eyes.



The dry cell is held in place by a strip of metal cut from a tin can.

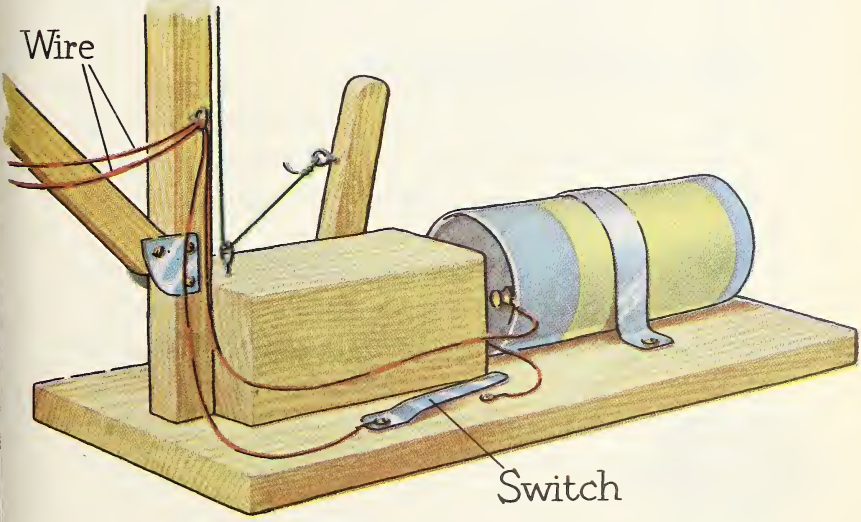




Put two washers on a stove bolt. Wind many turns of wire between the washers. This will be used as the electromagnet. Wrap a short piece of wire under the nut of the stove bolt and twist the wire into a loop. Fasten a string from the loop to a screw eye in the end of the boom.

One wire of the electromagnet goes to the dry cell. The other wire goes to the switch. A short wire goes from the switch to the dry cell.

Push the lever forward to lower the electromagnet into a pile of nails. Then press the switch and pull back on the lever. The magnet will lift some of the nails. Open the switch to drop the nails.

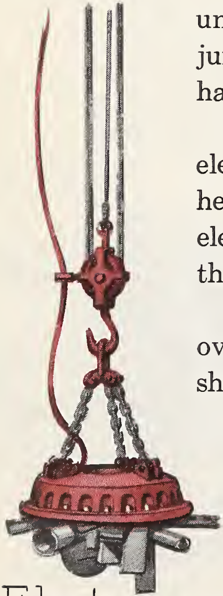


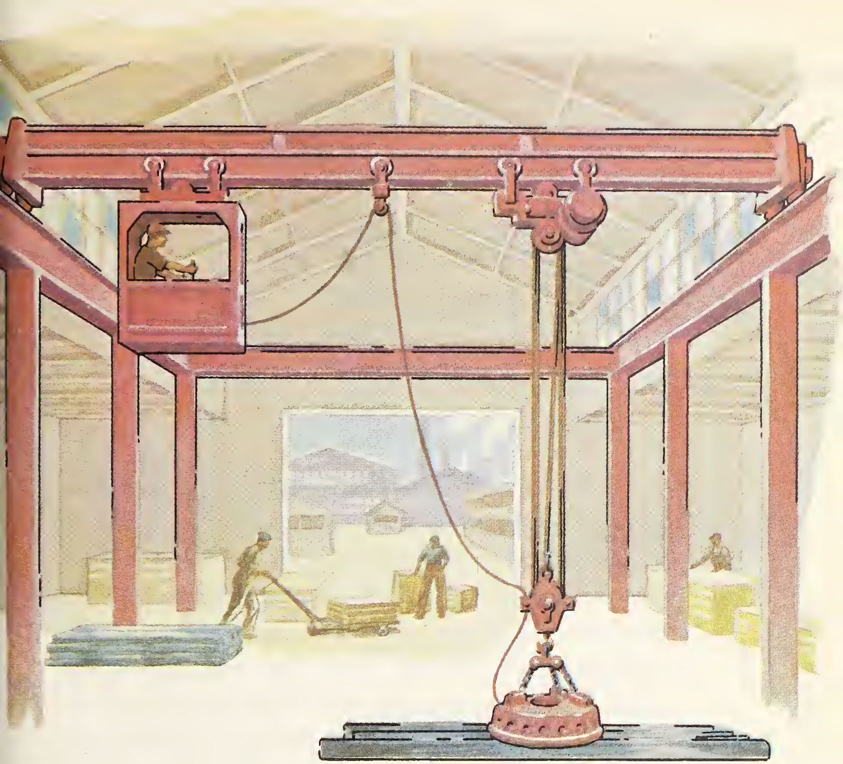
## Electromagnetic Cranes in Use

Electromagnetic cranes are used to load and unload steel scrap. You can see them in junk yards and on docks where steel scrap is handled.

The man who runs the crane lowers the electromagnet into a pile of steel scrap. Then he turns on the electricity and raises the electromagnet. Many pieces of steel cling to the magnet.

Next, he moves the crane until the steel is over a railroad car, a truck, or a barge. He shuts off the electricity and the scrap drops.

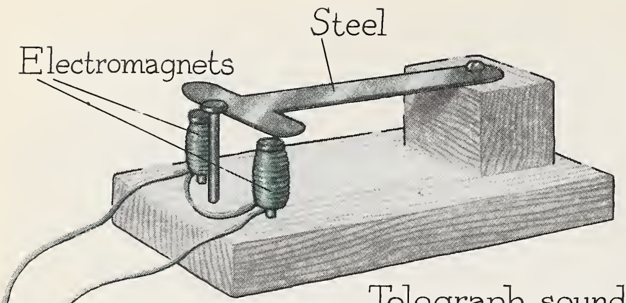




Several kinds of cranes are used for handling steel. In factories, the cranes often run on tracks near the tops of the buildings.

Electromagnets are used in factories to carry large bars and sheets of steel from one place to another. They are also used to gather up bits of scrap steel that are left around the machines.

Can electromagnetic cranes be used to handle lumber, copper, or aluminum? Explain your answer.



| | |
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| C | —•— |
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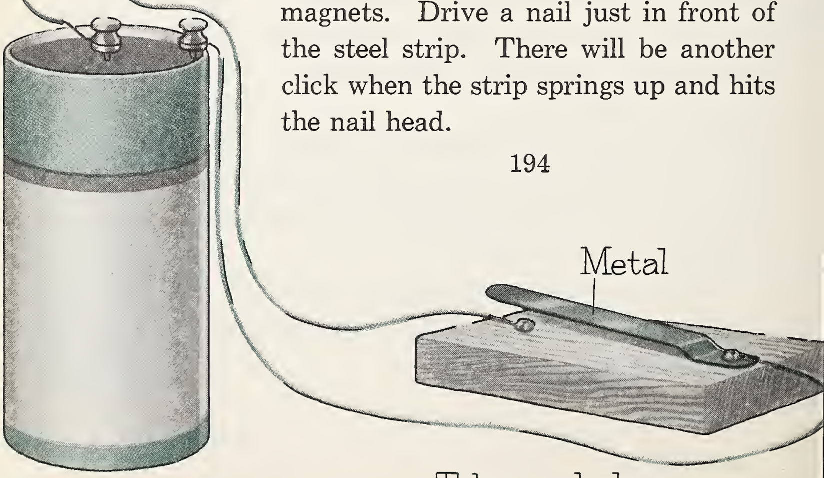
| F | ••—• |
| G | ——• |
| H | •••• |
| I | •• |
| J | •—— |
| K | —•— |
| L | •—•• |
| M | —— |

## The Telegraph

Here is a model telegraph set for you to make. The key is like the switches you have made.

The sounder has two electromagnets. They are wound on nails driven into a block of wood. The moving part of the sounder is a strip of steel. You can cut it from a tin can, which is really made of steel covered by a coat of tin.

This sounder makes a click when the steel strip is pulled down by the electromagnets. Drive a nail just in front of the steel strip. There will be another click when the strip springs up and hits the nail head.



N — ·
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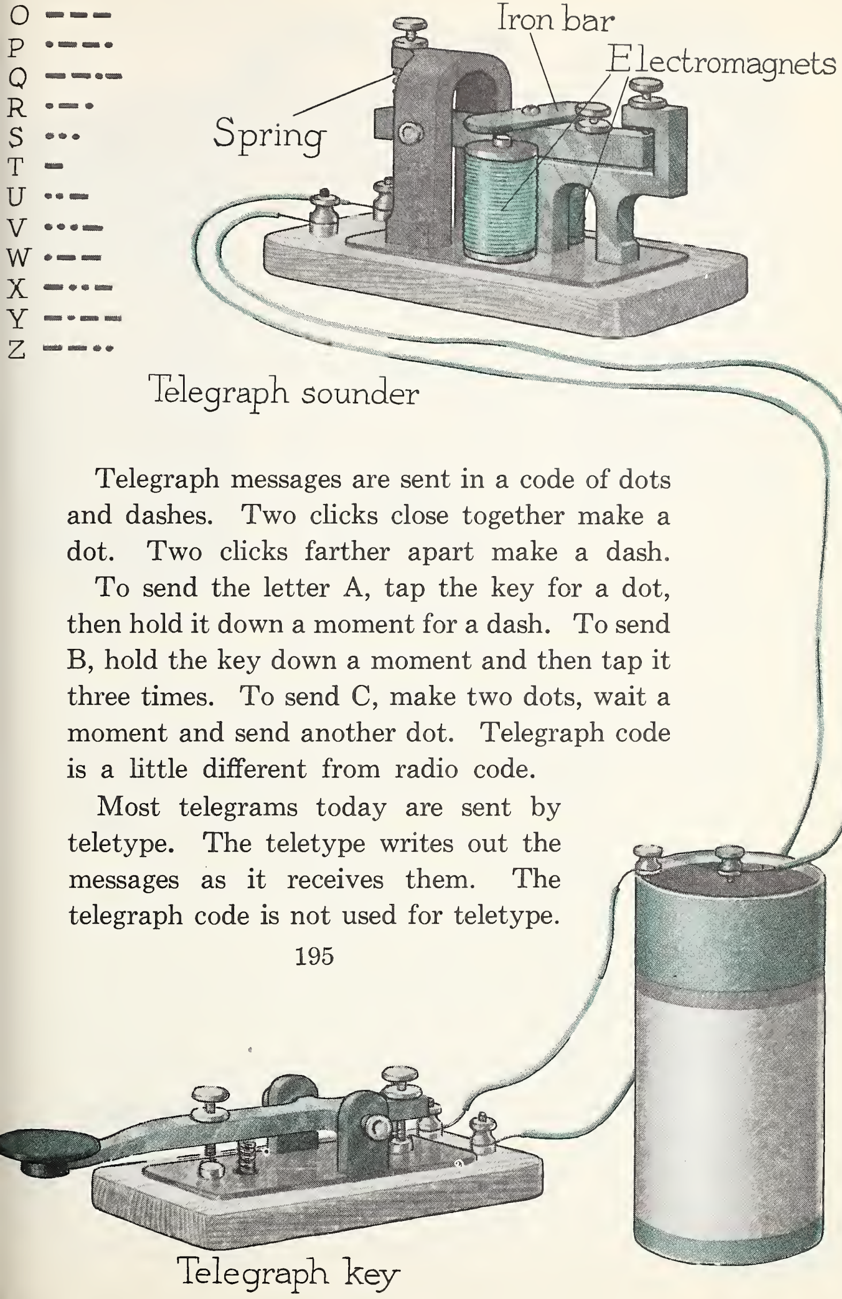


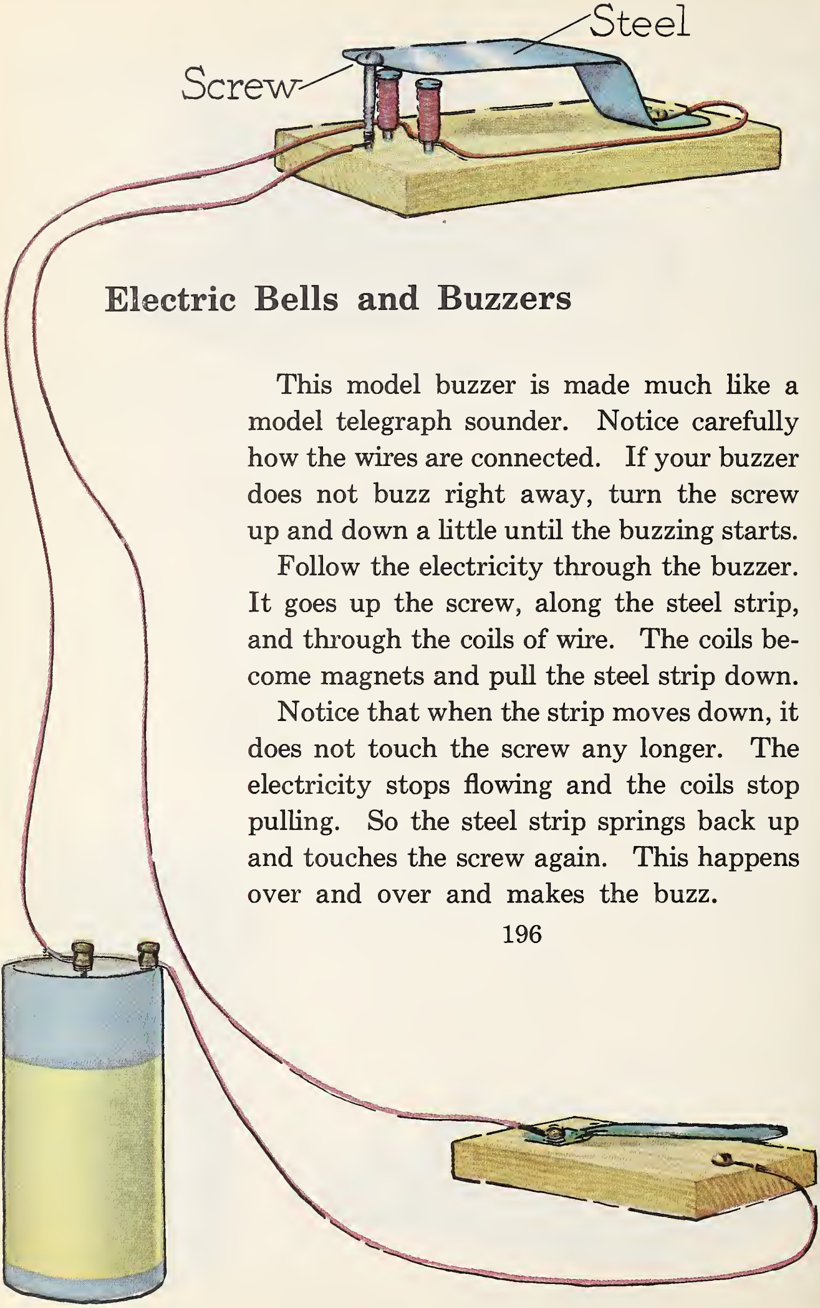
Telegraph sounder

Telegraph key

Telegraph messages are sent in a code of dots and dashes. Two clicks close together make a dot. Two clicks farther apart make a dash.

To send the letter A, tap the key for a dot, then hold it down a moment for a dash. To send B, hold the key down a moment and then tap it three times. To send C, make two dots, wait a moment and send another dot. Telegraph code is a little different from radio code.

Most telegrams today are sent by teletype. The teletype writes out the messages as it receives them. The telegraph code is not used for teletype.

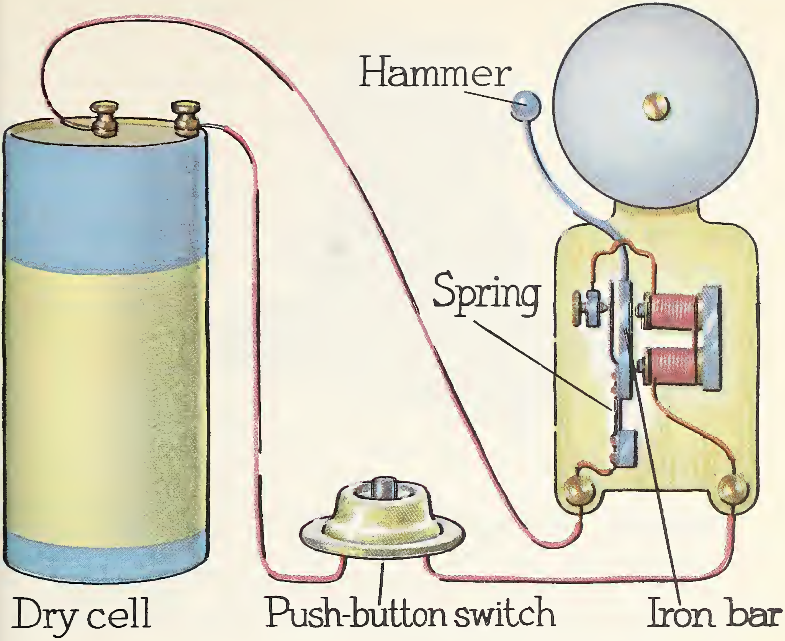


## Electric Bells and Buzzers

This model buzzer is made much like a model telegraph sounder. Notice carefully how the wires are connected. If your buzzer does not buzz right away, turn the screw up and down a little until the buzzing starts.

Follow the electricity through the buzzer. It goes up the screw, along the steel strip, and through the coils of wire. The coils become magnets and pull the steel strip down.

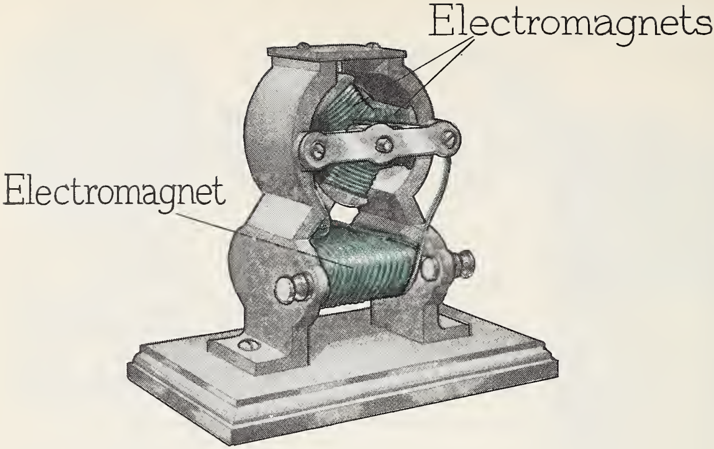
Notice that when the strip moves down, it does not touch the screw any longer. The electricity stops flowing and the coils stop pulling. So the steel strip springs back up and touches the screw again. This happens over and over and makes the buzz.



Electric bells and buzzers are made much alike. Connect an electric bell, a push button, and a dry cell. Push the button and watch the hammer move back and forth against the bell.

Find the electromagnets. Look for the iron bar near one end of the electromagnets. The hammer is fastened to this bar. Push the bar toward the coils and notice that the hammer hits the bell. Look for the spring that pulls the iron bar back when you take your finger away.

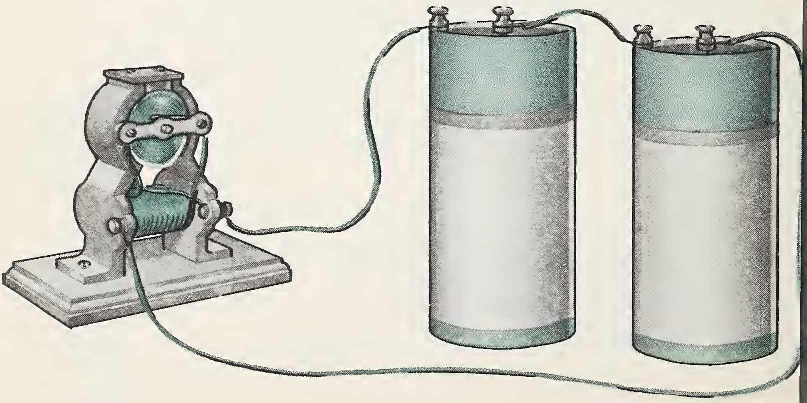
Electric bells work like the model buzzer you just made. Study the bell and see if you can explain it.



## Electric Motors

There are electromagnets in electric motors. Look inside an electric motor. Notice the coils of wire. These are the electromagnets.

Perhaps someone will bring a toy electric motor to school. Look for the electromagnets. Connect the motor to some dry cells and watch it run.

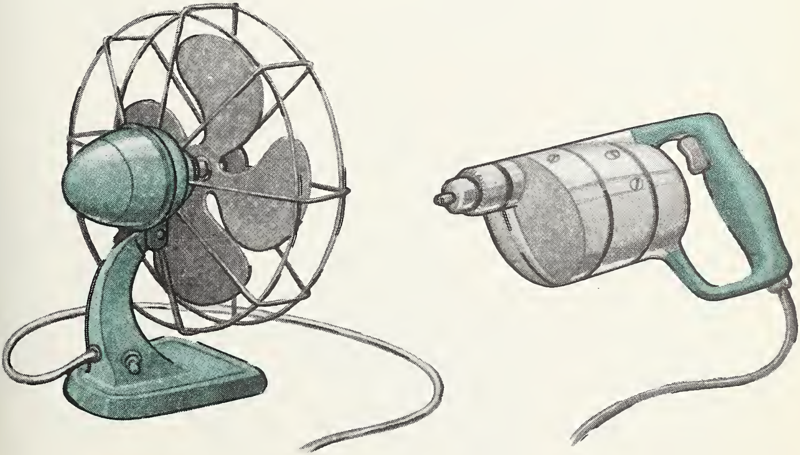


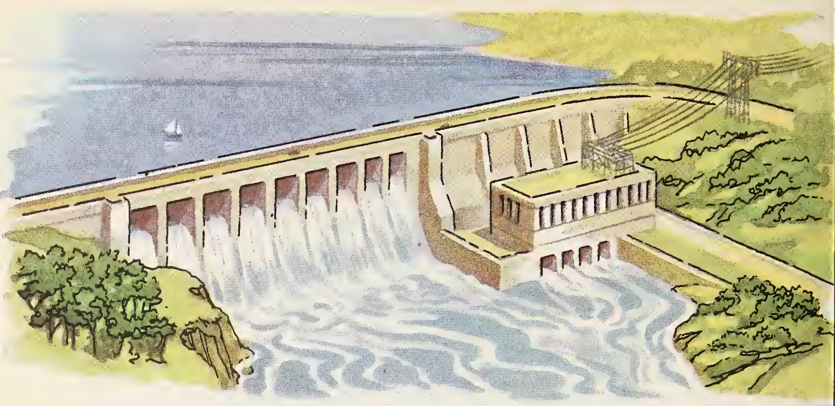
Make a list of ways that electric motors are used. Find pictures of machines that use electric motors and put them on your bulletin board.

A hundred years ago there were no electric motors. Much of the energy for machines came from the muscles of people and horses. Some of the energy came from wind and falling water. Some of it came from steam engines that burned wood and coal.

Electrical energy is easier to use than these other kinds of energy. It can be carried for miles in small wires. It is ready to be used the moment you touch a switch. There are no ashes and there is no smoke. There is little or no noise.

Think about some of our common machines, such as fans and washing machines. How would we make them run if there were no electricity?





## Where Electricity Gets Its Energy

The electrical energy we use comes to us from machines called generators. As generators spin, they make electricity flow through wires. The generators are turned by water turbines or steam turbines. Thus you see that most of our electricity gets its energy from the energy of coal and falling water. The electrical energy is then changed in our homes and factories to other kinds of energy such as heat and the energy of moving things.

---

1. How many poles does an electromagnet have?
2. How can you change the strength of an electromagnet?
3. What happens when you change the direction of the electricity in an electromagnet?
4. What are some ways electromagnets are used?
5. Why is electricity so important today?
6. Where does most electrical energy come from?

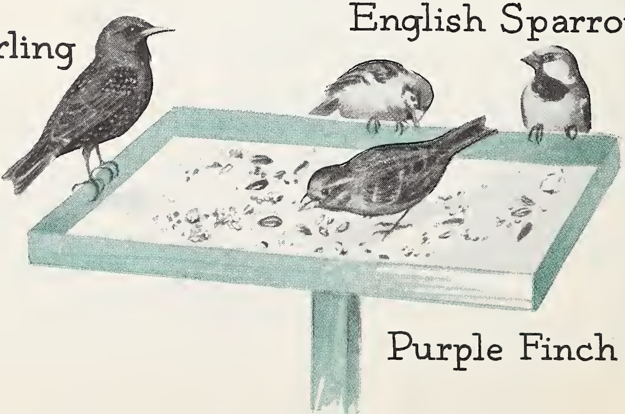
# Bird Study

## Getting to Know Birds

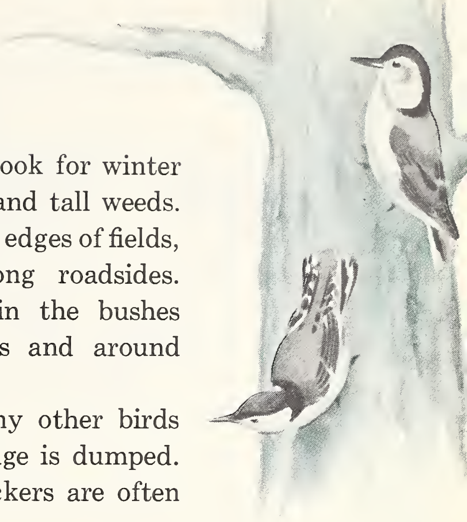
Winter is a good time to begin the study of birds. Visit places where you can see winter birds. Become acquainted with as many kinds as you can before the spring birds come.

There are usually winter birds around feeding stations if plenty of food is kept in them. The best time to see the birds is in early morning when they are hungry.

Perhaps you would like to start a feeding station. Make a shelf or a tray on a post. Put a roof over it if you wish. Keep seeds and crumbs in the tray. Keep some beef fat under a piece of wire screen for the small, meat-eating birds.



Nuthatch



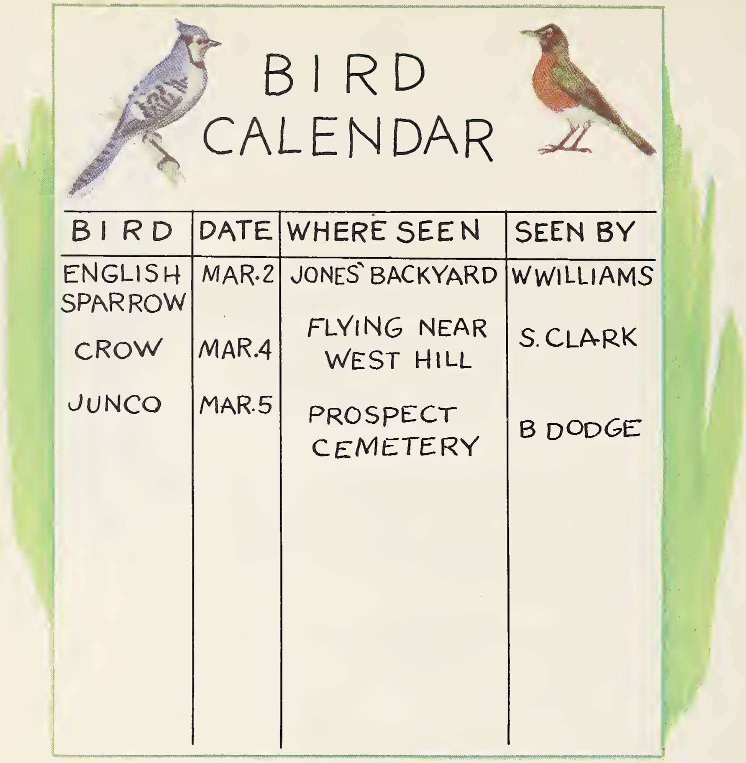
Other good places to look for winter birds are in low bushes and tall weeds. Look in vacant lots at the edges of fields, along streams, and along roadsides. There are often birds in the bushes that are found in parks and around houses.

Crows, gulls, and many other birds go to places where garbage is dumped. Chickadees and woodpeckers are often seen in the woods.

When you see a new bird, read about it in a bird book. Find out what it eats. Find out whether it looks the same in the winter as in the summer. Find out where it lives in the summer.

Junco

Tree Sparrow



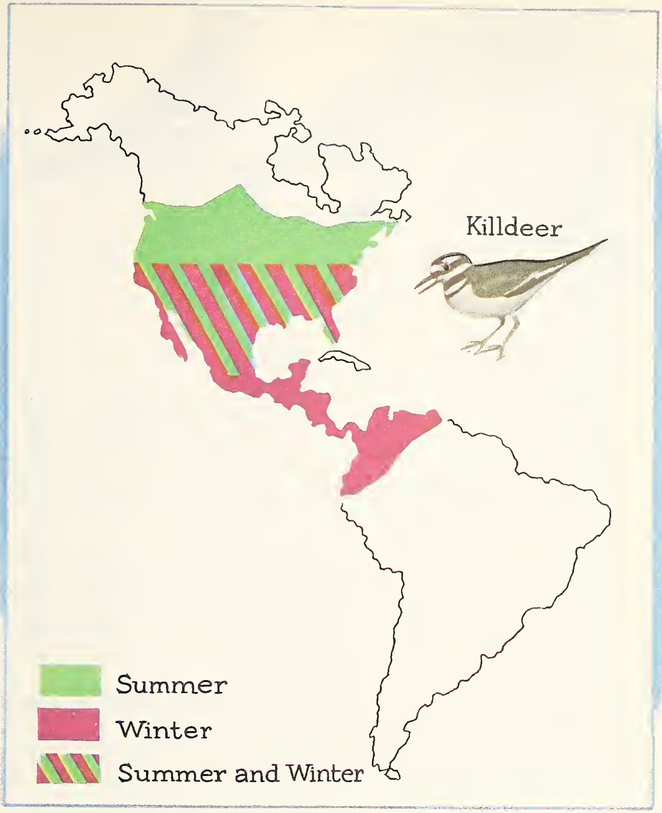
BIRD CALENDAR

| BIRD | DATE | WHERE SEEN | SEEN BY |
|---|---|---|---|
| ENGLISH SPARROW | MAR. 2 | JONES' BACKYARD | W WILLIAMS |
| CROW | MAR. 4 | FLYING NEAR WEST HILL | S. CLARK |
| JUNCO | MAR. 5 | PROSPECT CEMETERY | B DODGE |

## Keeping Records

A good way to keep a record of the new birds you see is to make a bird calendar. The whole class may have a calendar. Each person may also have a calendar if he wishes.

Write down the name of each new bird, where it was seen, and the date it was first seen. You may also wish to write down what the bird was doing.



When you see a new bird, find out where it lives in the winter and where it lives in the summer. Most bird books will tell you this.

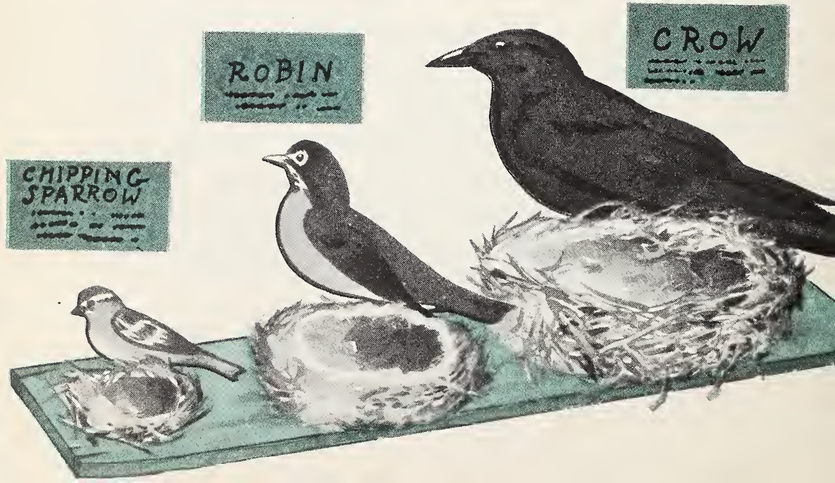
Then make a map like the one above. Use green for the places the bird lives in summer. Use red for the places it lives in winter. Make green lines and red lines in the places where the bird lives in both summer and winter.

## Bird Nests

You can learn much about birds by studying their nests. The birds do not use their nests in winter so you can collect them then. The birds usually build new nests in the spring.

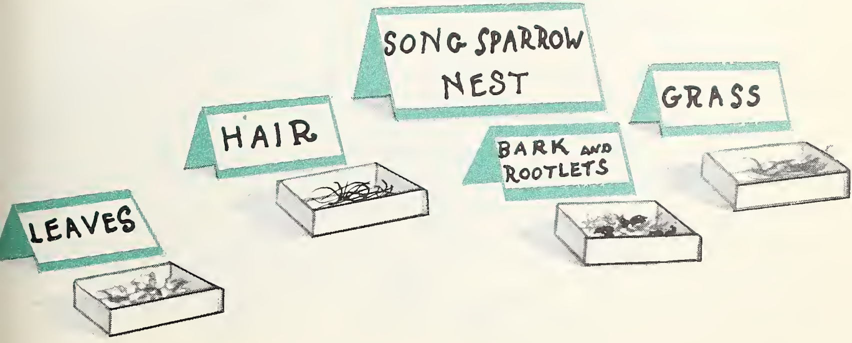
Each time you find a nest, write down where you found it. Then try to find out the name of the bird that built the nest. Bird books and people who have studied birds can help you.

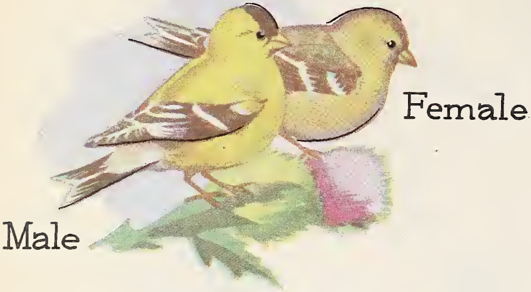
Make a picture of the bird that built the nest. Cut out the picture and put it with the nest. Do the same with other nests.



Take apart an old bird's nest. Sort the things it is made of and put them in different piles. Make a sign that tells where the nest was found and what bird made it.

You will find that some nests are made of twigs and bark. Some are made of grasses, tiny roots, and hair. Other nests are made of string, hair, and threads from plants. You will find thistle down in some nests and mud in others.



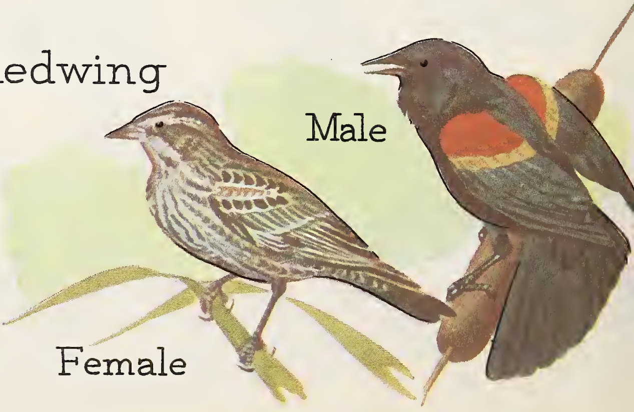


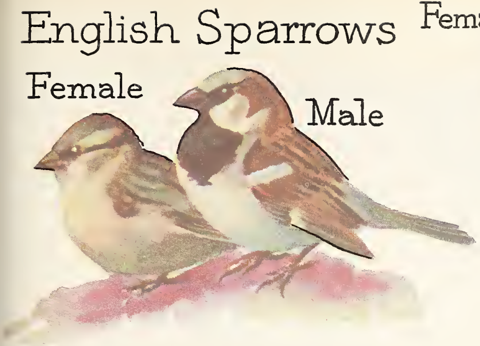
## Male and Female Colours

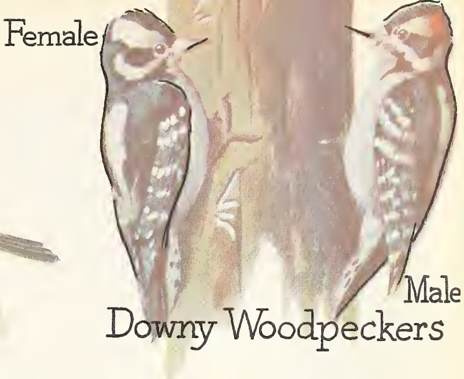
You may see two birds that do not look alike building the same nest. You are probably looking at a male and a female bird.

Look at pictures of goldfinches, redwings, orioles, and tanagers. Notice that the males and females are so different that they do not seem to be the same kind of bird. Find pictures of other males and females that do not look alike. Look for them on your field trips.

Draw pictures of the males and females of some of these birds. Make a game with the pictures to see how many males and females you can put together correctly.



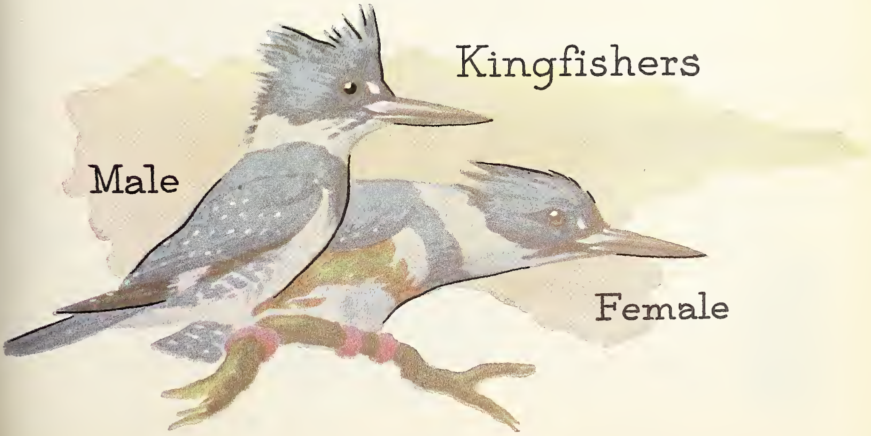


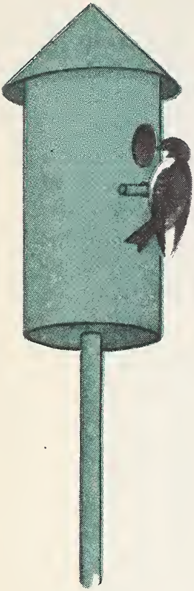


Males and females of other kinds of birds look almost alike. You must look closely to see how they are different. A male English sparrow has a black bib and the female does not have one. The female kingfisher has a brown belt and the male does not have one.

The males and females of some kinds of birds look so much alike that you cannot tell them apart. You cannot tell a male crow from a female crow or a male song sparrow from a female song sparrow.

Learn the differences between the males and females of as many kinds of birds as you can. When you can tell them apart, write on your bird calendar the names of the ones you have seen.



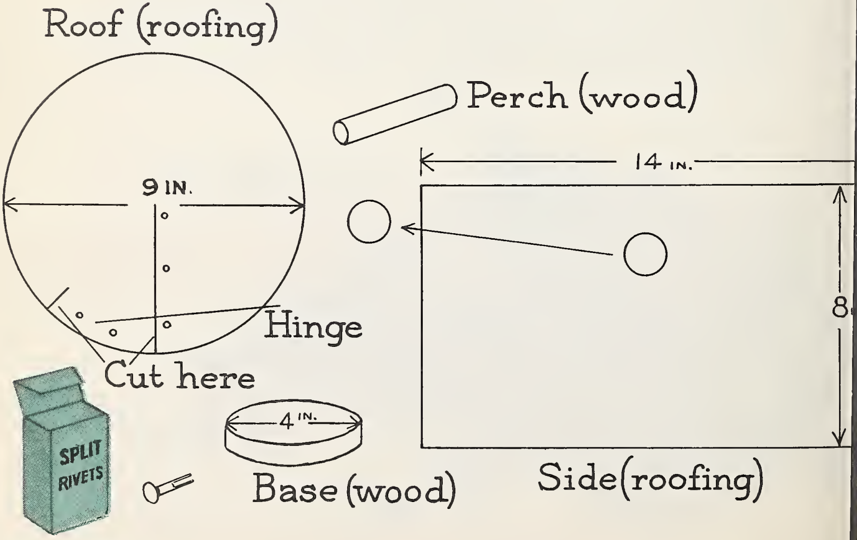


# Making a Birdhouse

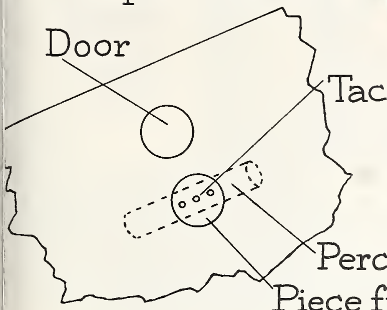
A birdhouse near your home will help you study birds. You can watch the birds day after day as they take care of their young.

You can make a good birdhouse from roofing paper and a few pieces of wood. First saw out a round piece of wood for the bottom of the house. Bore a small hole in the centre of the wood for a nail. Then nail the piece of wood to the end of a long pole.

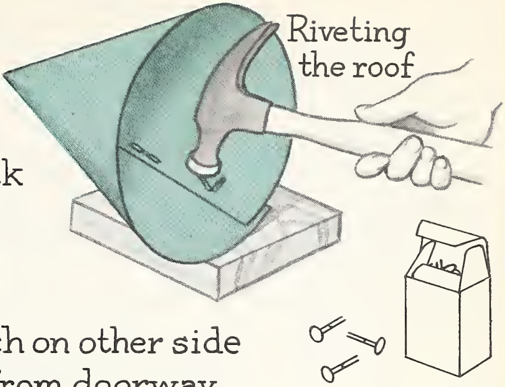
Cut a rectangle of roofing paper for the side of the house. Cut a hole in it for the door. Save the piece you cut out. Cut a circle of roofing paper for the roof of the birdhouse.



How the perch is fastened



Riveting the roof



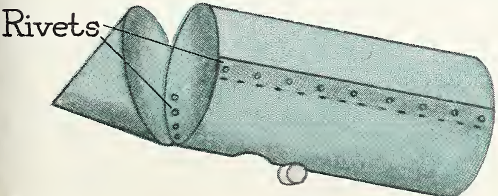
Fasten the perch below the door with large tacks. Use the small piece of roofing paper from the doorway to strengthen the side where the tacks go through. The picture shows how to do this.

Form the roof into a cone and rivet it together. Then rivet the part of the roof marked "hinge" to the side of the house.

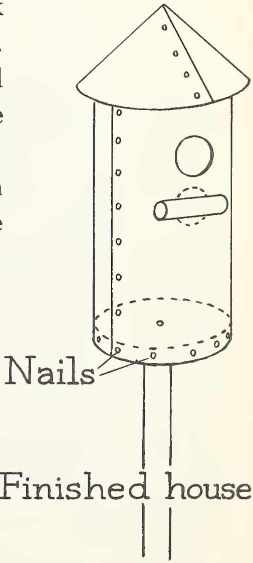
Roll the side of the house and rivet the edges together. The house should now look like the picture at the bottom of the page.

Nail the house to the round piece of wood that makes the bottom of the house. Use big-headed nails.

A good place for the house is a garden or a field where it will be shaded during the middle of the day.



Roof riveted to side



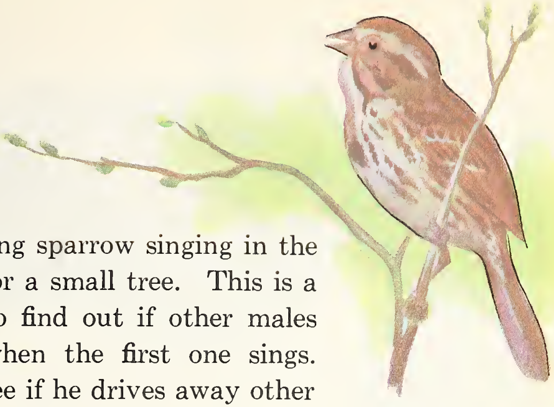
Finished house

## Territories

Many male birds set up territories for nesting and feeding. Then each male tries to keep other males out of his territory.

A male song sparrow chooses for his territory a place where there are shrubs, small trees, and thickets. He goes to the centre of his territory and begins to sing. The song seems to be a warning for other male song sparrows to stay out.

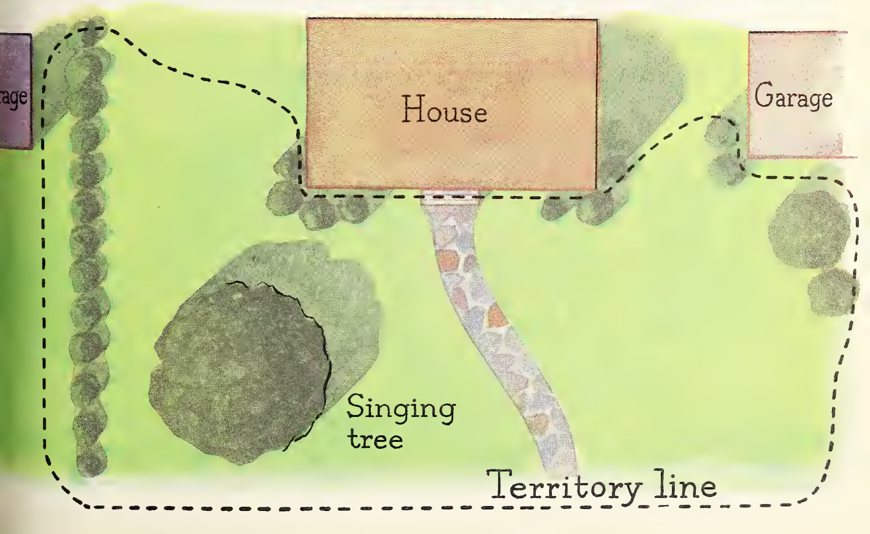
If another male comes into his territory, the first male tries to drive him out. They may fight. The first male usually wins, but sometimes he loses his territory.

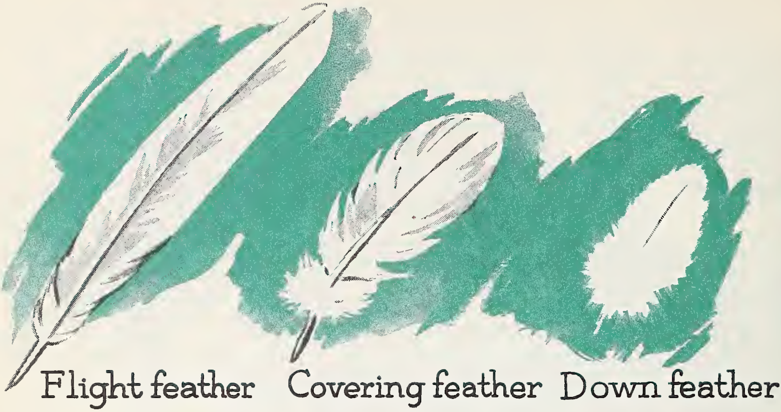


Look for a song sparrow singing in the top of a shrub or a small tree. This is a male. Listen to find out if other males start to sing when the first one sings. Watch him to see if he drives away other song sparrows.

If a song sparrow sets up a territory near your home, try to find out how big his territory is. Make a map. Mark on the map the places where the song sparrow does most of his singing.

Watch the song sparrow drive away other males. Notice where he stops chasing them. You will soon be able to draw a line on your map to show where his territory is.

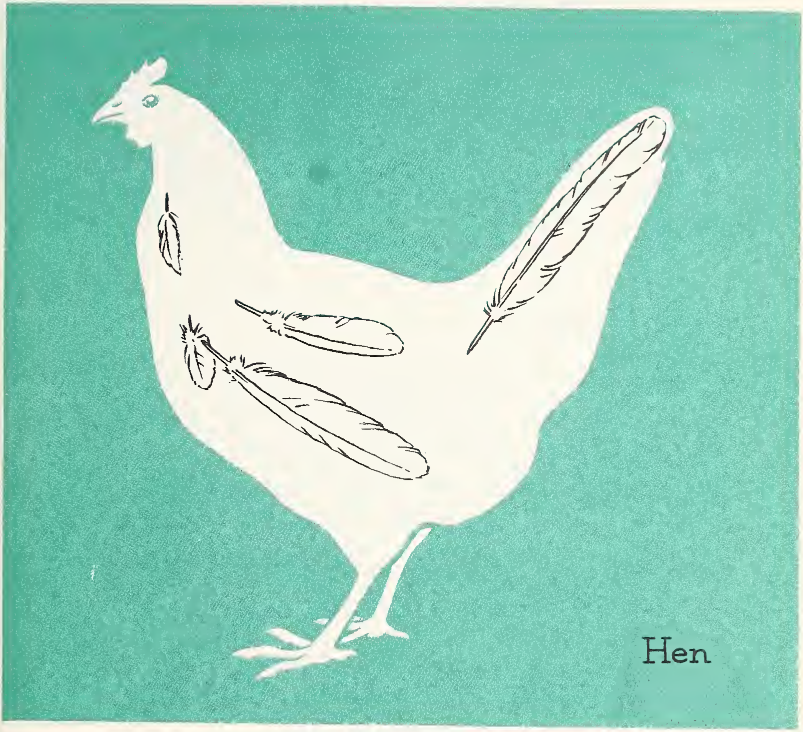




## Feathers

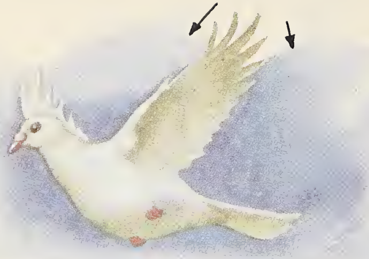
Look at different kinds of feathers. Notice the stiff feathers from the wing of a bird. How does a bird use these feathers? Notice the feathers that cover the bird as shingles cover a house. Pour some drops of water on them and note what happens. Look for the down feathers that keep the bird warm.

Notice how light feathers are. Why is this helpful to a flying bird? Notice the way feathers are made. Perhaps you can look at a feather under a microscope and see the tiny hooks that hold the stiff parts together.

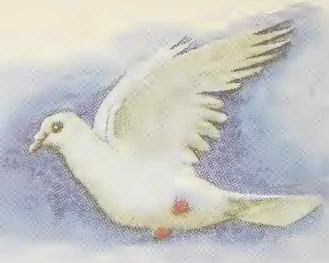


Get the feathers of a large bird such as a hen or a rooster. Pick out the wing feathers and the tail feathers. Pick out some of the covering feathers. Then make a life-size drawing of the bird and glue the different feathers in the proper places on the drawing.

You may find some bird feathers. Bring them in and make a chart like the one above for each kind of bird.



Going down



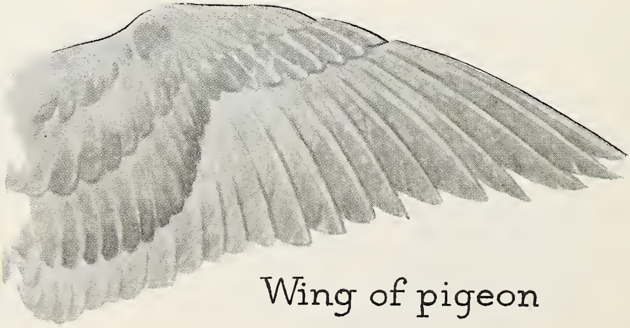
Going up

## Bird Flight

Wave a large wing feather downward. Notice how the air pushes up on the feather. Now wave the feather upward without turning it over. Notice how easily the feather moves. The air slips past it easily.

When a bird moves its wings downward, the air pushes up on the feathers. This makes the bird rise. When the wings go up again, the air slips easily between the feathers.

Take the feathers from a dead bird's wing. Mount them on a chart that shows how the feathers are arranged in a wing.

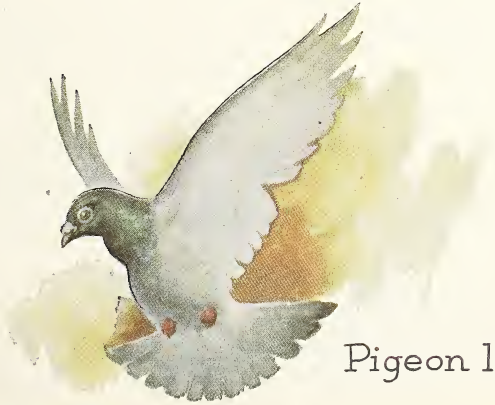


Wing of pigeon

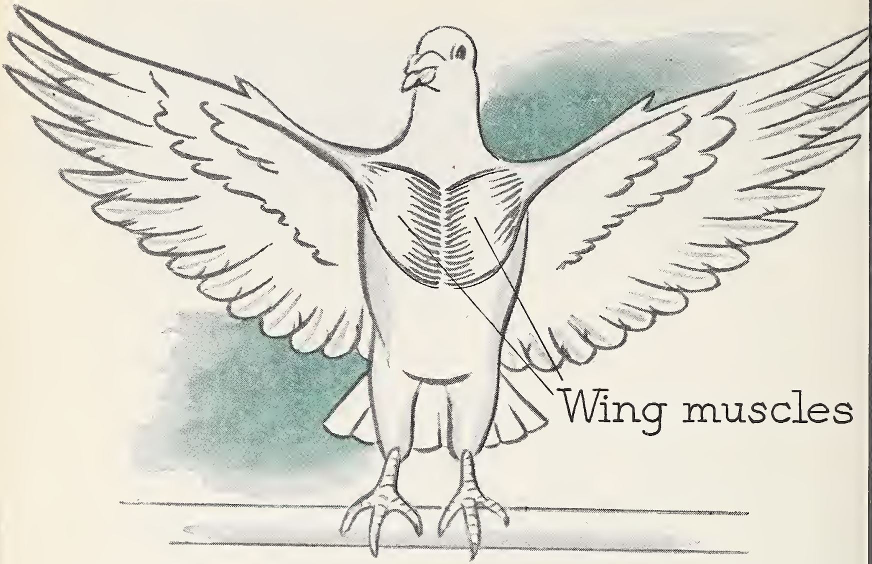
Watch birds flying. Notice that different kinds of birds have different ways of flying. Some move their wings rapidly and some move them slowly. Some flap their wings two or three times, glide a few feet, and then flap their wings again.

Some gulls and hawks have light bodies and large wings. They do not flap their wings as often as heavier birds do. At times you may see them soar without flapping their wings at all.

Most birds use their tails to help steer themselves during quick turns. They also use their tails to keep themselves balanced. They often use them to slow their speed before landing. Watch a pigeon as it lands and notice the way it uses its tail.

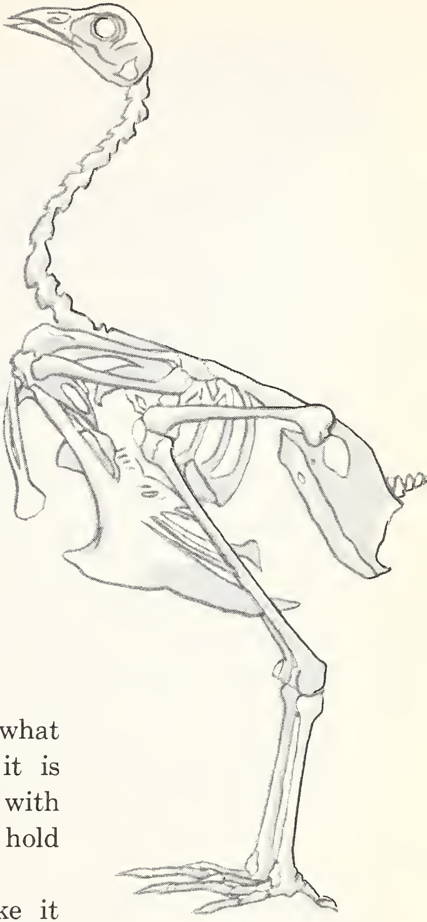


Pigeon landing



The biggest muscles in most birds are the muscles that flap the wings downward. These muscles are in the breast of the bird. Have you noticed that most of the meat of a chicken is in the breast? The breast meat of a chicken is made up of wing muscles.

A bird's wings are much like your arms and have many of the same muscles. Pretend one of your arms is a wing. Push it down against a table top and feel your chest with your other hand. Find the muscles that become hard. Muscles like these pull a bird's wing down.



Bring the bones of a chicken or a turkey to school. Clean them by boiling them in soap and water.

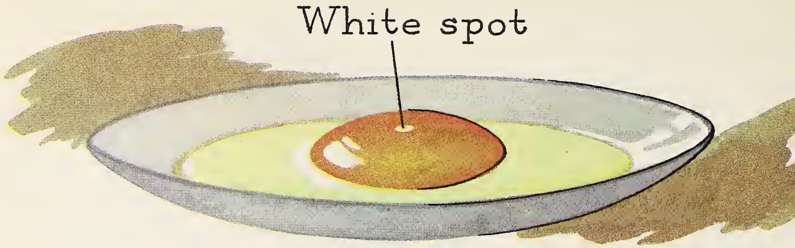
Try to find some of the same bones in this picture. Which ones are somewhat like the bones in your own body?

Find the breast bone. A bird needs a big breast bone to hold the wing muscles. Find your own breast bone. How is it different?

The "wishbone" is somewhat like your collarbone, but it is large and strong compared with the other bones. It helps hold the wing muscles.

Heavy bones would make it hard for a bird to fly. Break open the leg bone of a chicken. Notice that it is hollow. How does this help a bird?

Leg bone of hen

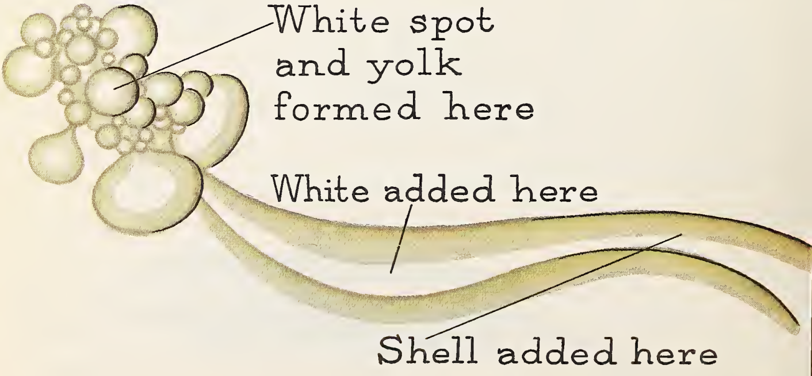


## Birds' Eggs

Look at the yolk of a hen's egg. You will see a little white spot on one side. This is the part of the egg that grows into a chicken. The yolk and the white are the food for the growing chicken.

Many birds lay an egg a day until there are four eggs in the nest. Hummingbirds stop when there are two eggs. Hens and ducks may lay ten or more eggs.

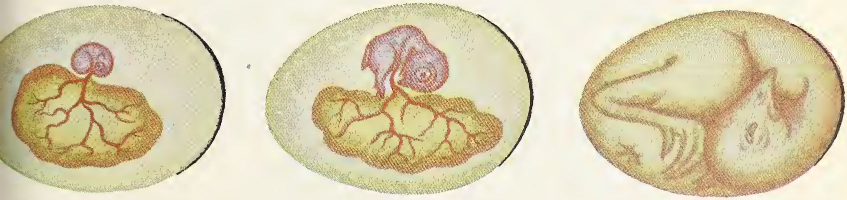
Eggs begin to grow in a long tube inside the female bird. The white spot and the yolk are formed at the upper end of the tube. As the egg moves along the tube, glands add first the white and then the shell. Then the egg is laid in the nest.



The female bird keeps the eggs dry and warm with her own body. The male bird may help her, but the males of many kinds of birds such as ducks and chickens do not help take care of the eggs or the young.

The white spot soon begins to grow. At first it does not look much like a bird. The heart and blood can be seen first. Then the head begins to show.

Later the eyes show and the legs and wings begin to grow. After two or three weeks the bird is fully formed. Then it picks a hole in the shell and comes out.



Baby robin

## The Care of Young Birds

Many kinds of young birds are helpless when they hatch. They are blind and they cannot walk. They have no feathers. They need much care before they are ready to leave the nest.

The mother bird keeps them warm and dry. She stays on the nest at night and during rains. During most of the day she hunts food for them. The males of some kinds of birds help take care of the young.

Watch a nest of young birds. Notice how often the parent birds bring food. Use a watch and a notebook to keep a record for a report to the class.

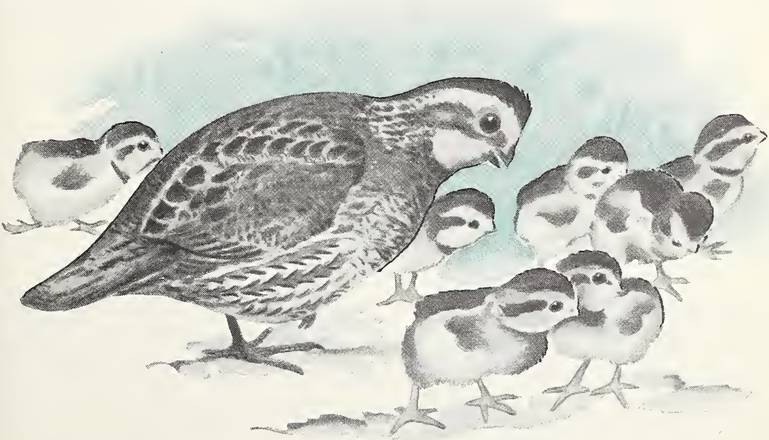
Female robin
and young robins

Baby bobwhite

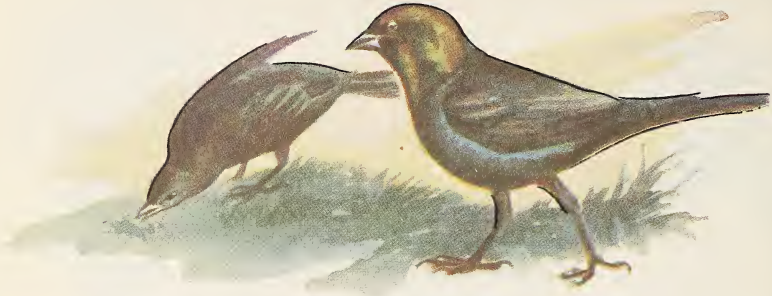
Some kinds of young birds are able to walk around as soon as they hatch. Perhaps you have seen young chickens, ducks, or turkeys walk around when they are very small. The young of wild ducks, pheasants, and grouse walk around also.

These young birds usually spend a longer time in the eggs. When they hatch they are covered with down. Their eyes are open. They can feed themselves.

The female bird leads her young birds to places where they can find food. She keeps them warm and dry at night. She tries to keep them from danger.



Female grouse and young



## Cowbirds

Cowbirds do not build nests. The females do not take care of their eggs or their young. Yet there are always many cowbirds.

The females lay their eggs in the nests of other birds. These other birds take care of the cowbirds' eggs and young along with their own. You will be interested in reading more about the habits of cowbirds.

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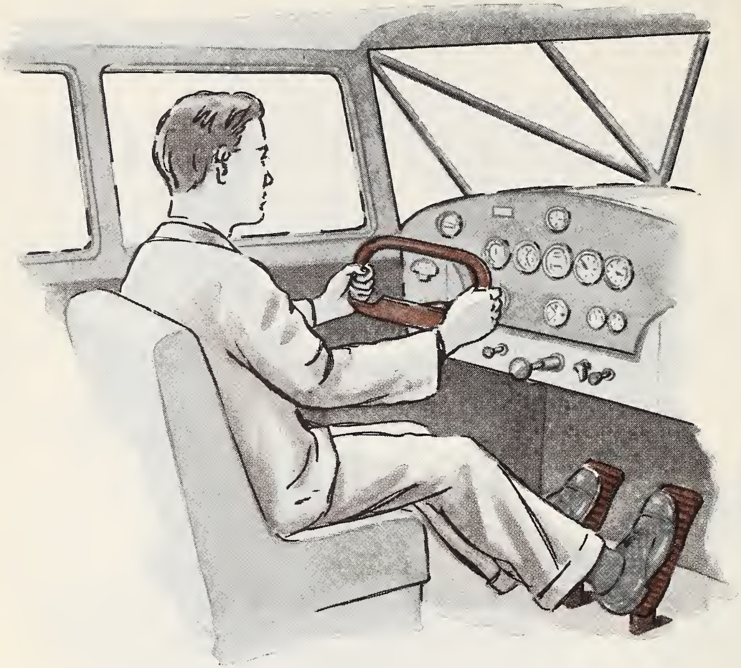
1. Name some birds that live near your home all through the year.
2. Name some birds that live near your home only in summer.
3. Tell how some kinds of young birds look when they hatch.
4. Which muscles are biggest in most birds?
5. How are feathers useful to birds?
6. Explain how you can tell the difference between some male and female birds.

# How Airplanes Fly

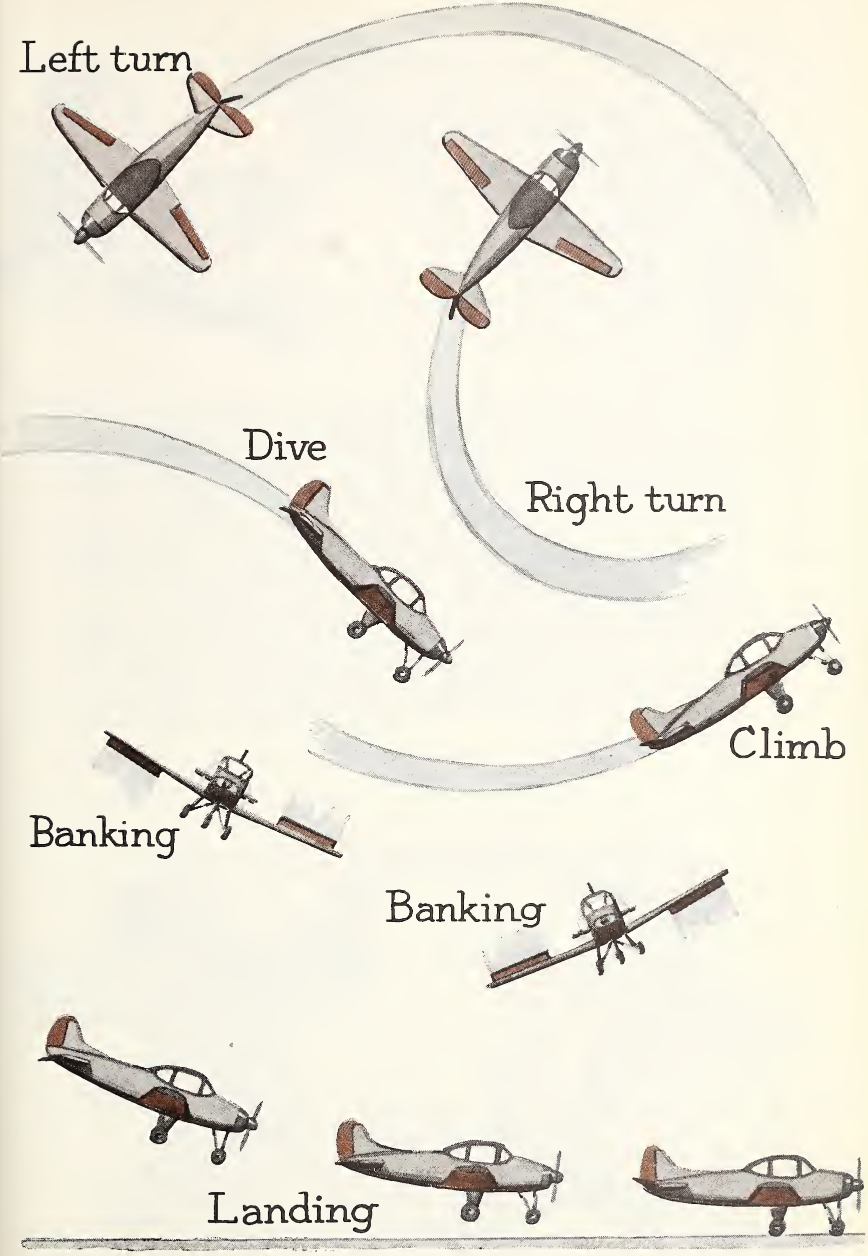


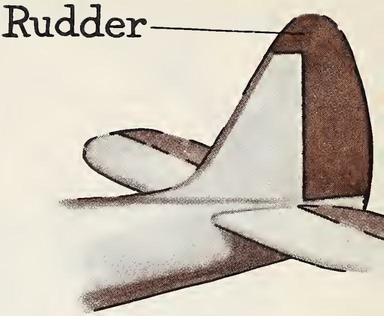
## Controlling an Airplane

This is the pilot's cabin of a small airplane. Look at the pedals and the wheel that the pilot uses to control the plane.

He steers the plane with the pedals. He pulls or pushes on the wheel to make the plane climb or dive. He turns the wheel to make the plane tip.

On the next page a plane is turning, climbing, and diving. Tell what the pilot uses to make it do each of these things.


Left turn
Dive
Right turn
Climb
Banking
Banking
Landing



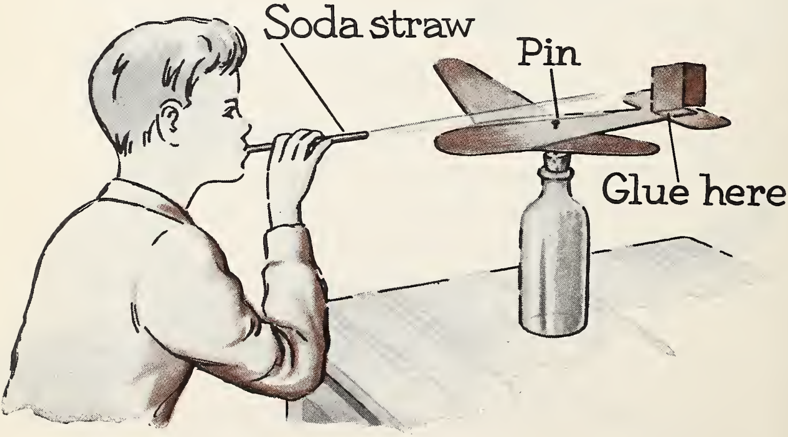
## Steering a Plane

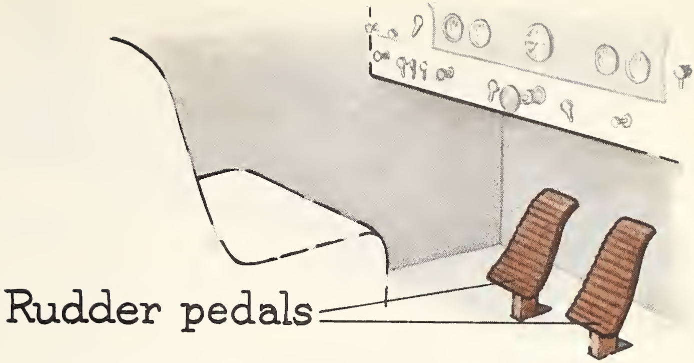
The rudder of an airplane makes the plane turn to the right or to the left. It is part of the tail of the plane.

Cut a piece of light cardboard in the shape of an airplane. Glue an upright piece of cardboard to the tail of the plane as shown in the picture below. The back of the upright piece will be the rudder.

Find the balancing point of the model. Push a pin through this point into the cork of a bottle.

Blow through a soda straw at the model plane. Bend the rudder to the left and blow at the model. Bend the rudder to the right and blow at the model. What happens each time?

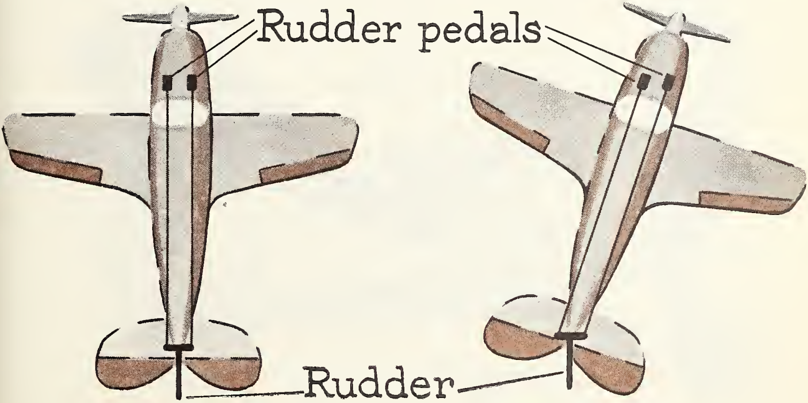


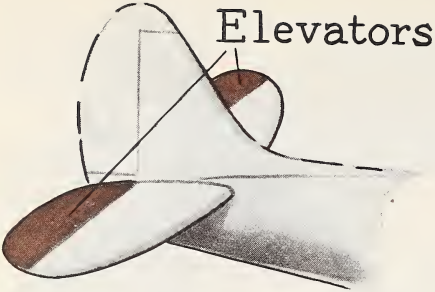


A pilot steers his airplane with his feet. There are two pedals in front of him. He pushes on the right pedal to make the plane turn right. He pushes on the left pedal to make the plane turn left.

A push on the right pedal turns the rudder to the right. The wind now presses on the rudder and swings the tail of the plane so that it turns to the right.

Explain why pushing on the left pedal makes the plane turn to the left.



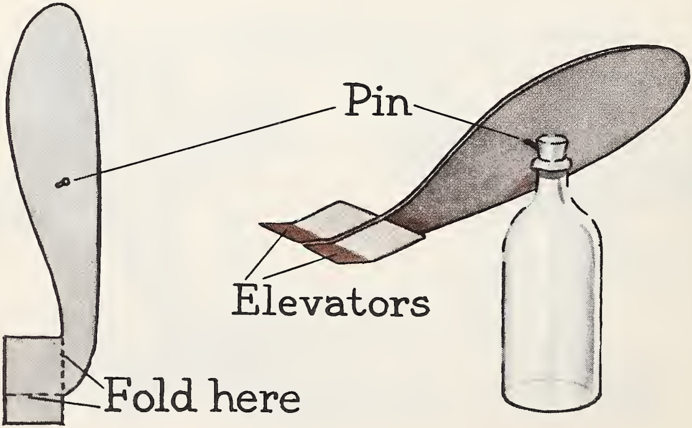


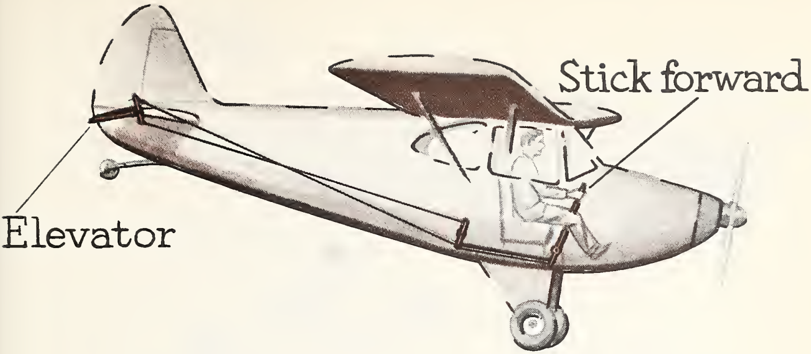
## Climbing and Diving

The elevators are used to make an airplane climb and dive. The elevators are part of the tail of a plane.

Cut some thin cardboard in the shape of the piece shown below. Cut another piece just like it. Bend over the tail pieces and glue the rest of the cardboard together.

Find the balancing point of this model. Push a pin through this point into a cork in a bottle. Bend the elevators up and blow through a straw at the model. Bend the elevators down and blow at it again.

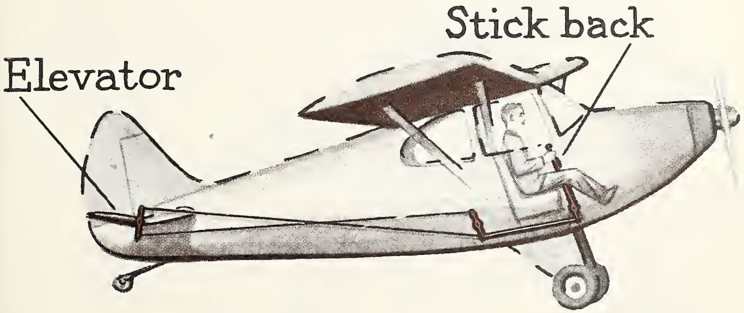


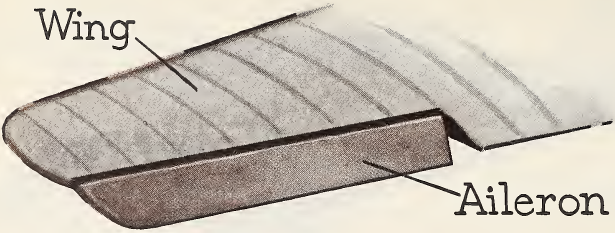


In some planes the pilot moves the elevators by pulling or pushing a wheel in front of him. In other planes, the pilot pulls or pushes a lever, called the "stick."

The pilot turns the elevators down by pushing on the wheel or the stick. The wind then pushes up against the elevators and pushes the tail up. The plane is now heading downward.

The pilot turns the elevators up by pulling on the wheel or the stick. When the elevators turn up, the wind presses against them. This pushes the back of the plane down and makes it head upward.



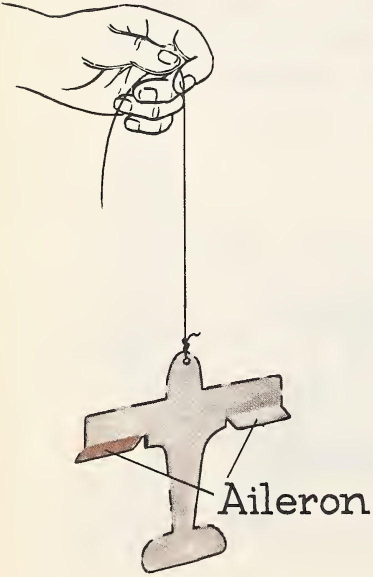


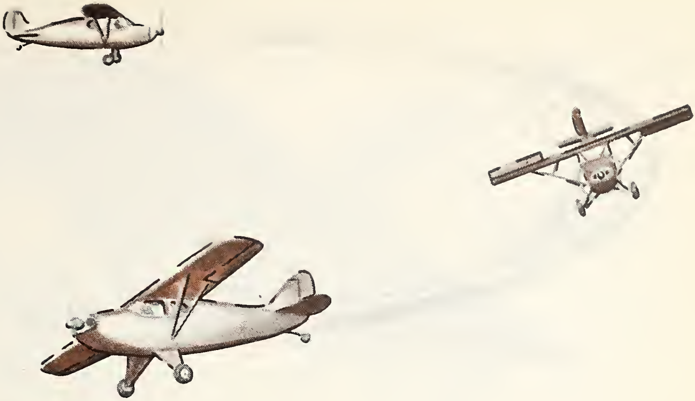
## Making a Plane Bank

The ailerons are on the ends of the wings. When one aileron is turned down, the other aileron is turned up. The ailerons can bank the airplane to one side or the other, and they can make the plane fly level again.

Cut some thin cardboard in the shape of a plane. Make a cut in the back of each wing so that you can bend a piece of the wing up and down as an aileron.

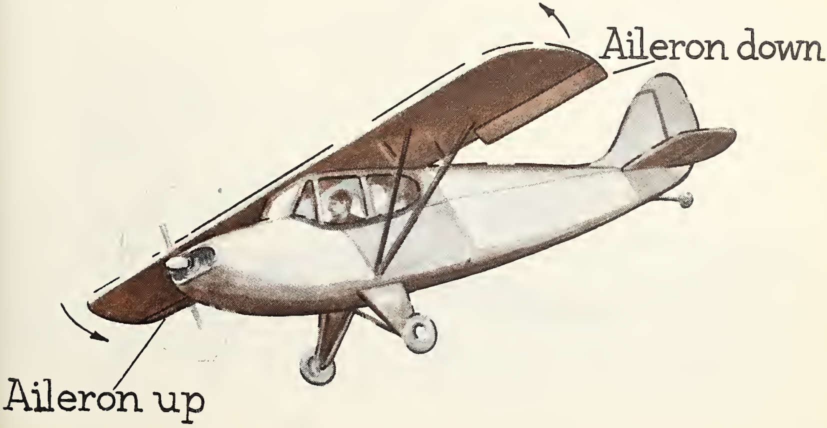
Fasten a thread to the nose of the model. Pull the model straight up slowly. Now bend one aileron up and the other aileron down. Pull the model up slowly again. What happens each time?

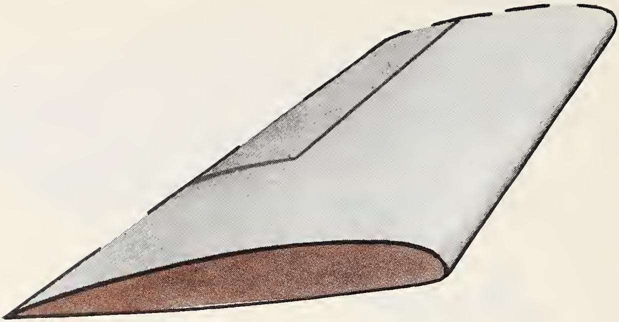




Have you noticed that roads are often banked on curves? This is so that automobiles do not slide off when they turn at high speed. Airplanes must be banked also so that they do not slip on turns.

The ailerons are moved by the stick or the control wheel. When a pilot pushes the stick or turns the wheel to the right, the left aileron goes down and the right aileron goes up. The wind now pushes down on the right aileron and up on the left aileron. That makes the plane bank to the right.

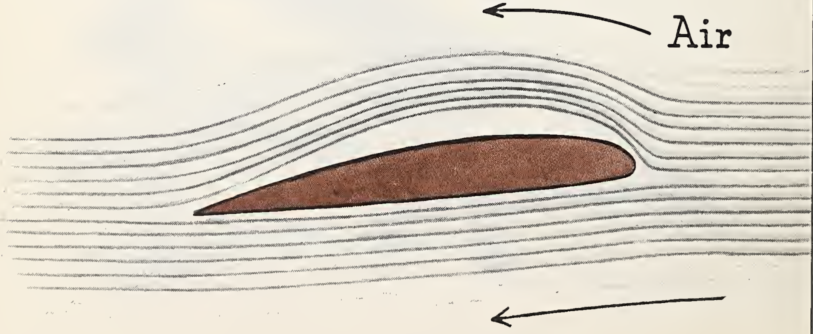




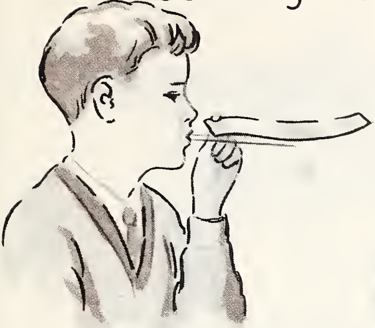
## An Airplane Wing

Some of the first airplane wings were flat. Years of experiments, however, have given us the shape of the wings we see on planes today. The modern airplane wing is curved on the top and nearly flat on the bottom; it is thin at the rear edge and thick near the front.

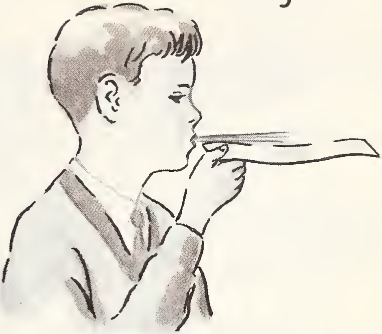
As the wing goes through the air, the air separates. Part of the air goes under the wing. Part of it goes over. It has been discovered that both the air over the wing and the air under the wing help to raise the wing.



Blowing under

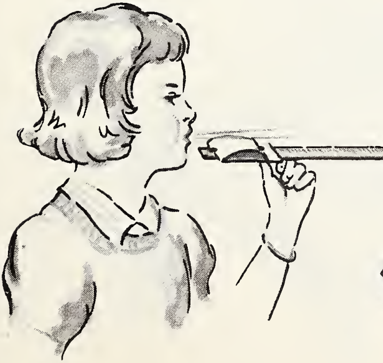


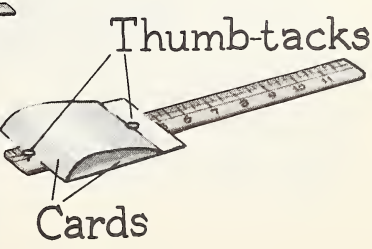
Blowing over

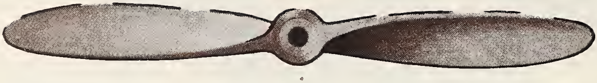


Put one end of a strip of paper against your upper lip and blow. What happens? Put the end of the strip against your lower lip and blow. What happens? Notice that air blowing over the paper raises the paper just as blowing under it does.

Lay a card on one end of a ruler. Use thumb-tacks to fasten another card on the first one so that the upper card is curved. Balance the ruler on your thumb. Blow over the curved card. What happens?





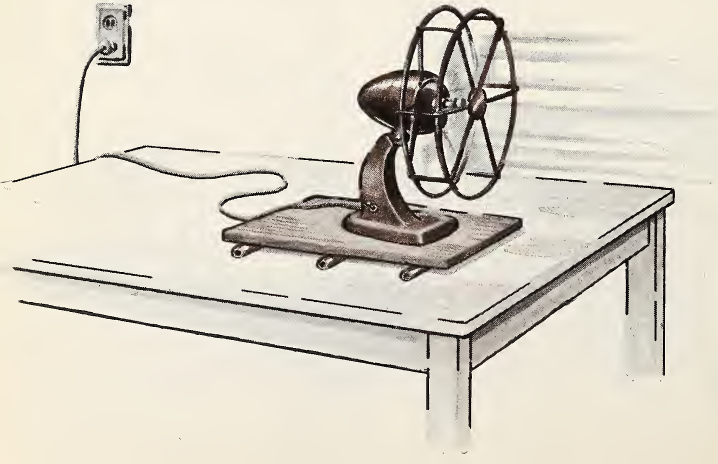


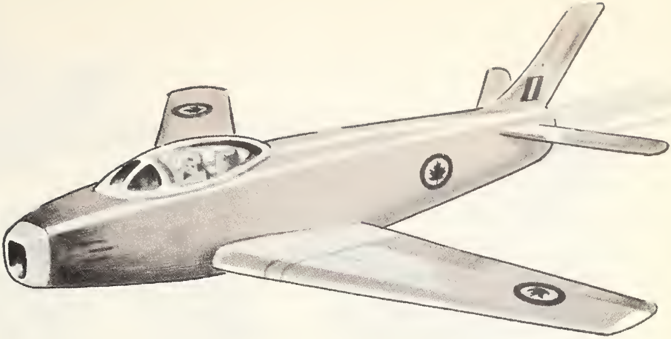
## Making Airplanes Move

All planes except jets and gliders use propellers. A propeller is something like an electric fan. There is a twist in each blade of a propeller. The propeller pushes back on the air as it turns.

Put a board on three round pencils on a table. Put an electric fan on the board. Turn on the fan and notice what happens.

As the air is pushed in one direction, the fan is pushed in the other. Airplanes are moved forward by the propellers in much the same way.



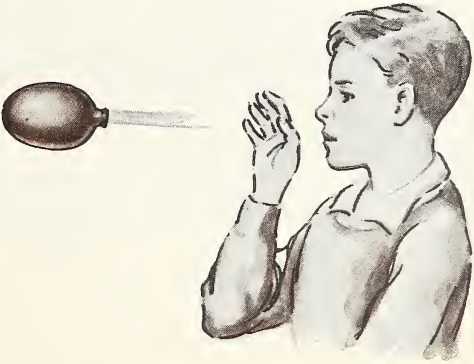


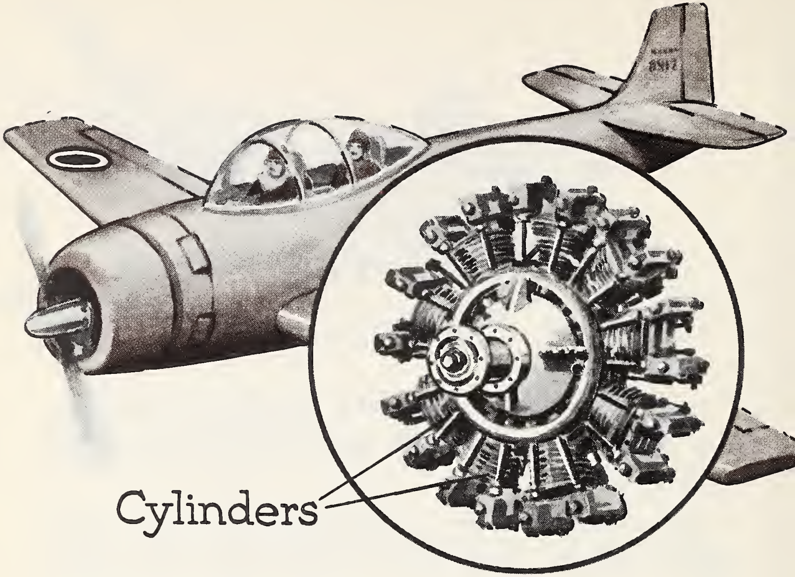
There are planes that have no propellers. Some are jet planes. Jet planes fly much faster than planes with propellers.

To understand how a jet plane moves, blow up a rubber balloon. Then let go of the balloon and watch it.

Air rushes out the mouth of the balloon. This moving air pushes back on the balloon. The push makes the balloon fly about until the air is gone.

In jet planes, hot gases from burning fuel rush from openings in the planes. The push of these gases drives the planes ahead.

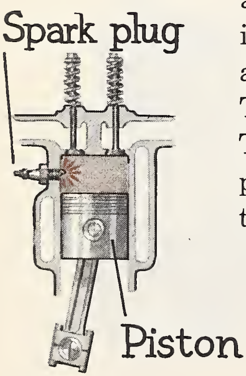




## Airplane Engines

Propeller-driven planes use gasoline engines. These engines work much like the gasoline engines in automobiles.

There are two or more cylinders in an airplane engine. Big engines have many cylinders.

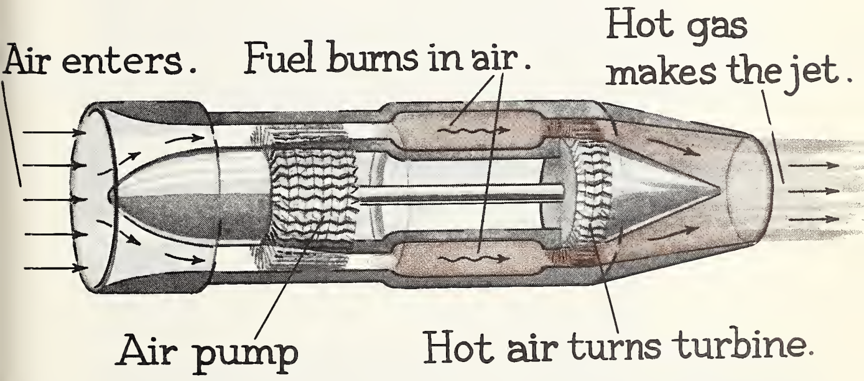


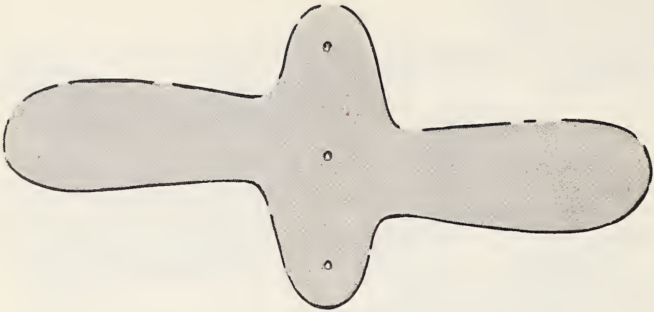
A cylinder is closed at one end and open at the other. A piston slides back and forth in the cylinder. Gasoline vapour and air are pumped into the cylinders of the engine. They are set on fire with an electric spark. The air becomes hot and grows bigger. It pushes on the pistons and makes a force that turns the propellers.

Jet engines have only a few moving parts. Air is pumped into the front of the engine by a rapidly whirling fan. This air is mixed with the fuel. The fuel burns and heats the air to a high temperature.

The air becomes much bigger as it is heated, and it rushes out the back of the engine with great force. This rushing air is called the jet. On its way out, the rapidly moving air spins a turbine that drives the air pump at the front of the engine.

Jet engines drive planes very rapidly, but they use more fuel than planes with gasoline engines. They also need longer runways for landing and taking off.

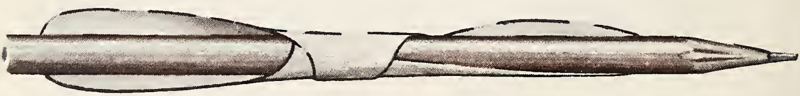




## Making a Propeller

Lay a sheet of thin paper on the above outline. Trace the outline. Then use carbon paper to make the same outline on thin cardboard. Cut around the outline and punch three holes in it as shown.

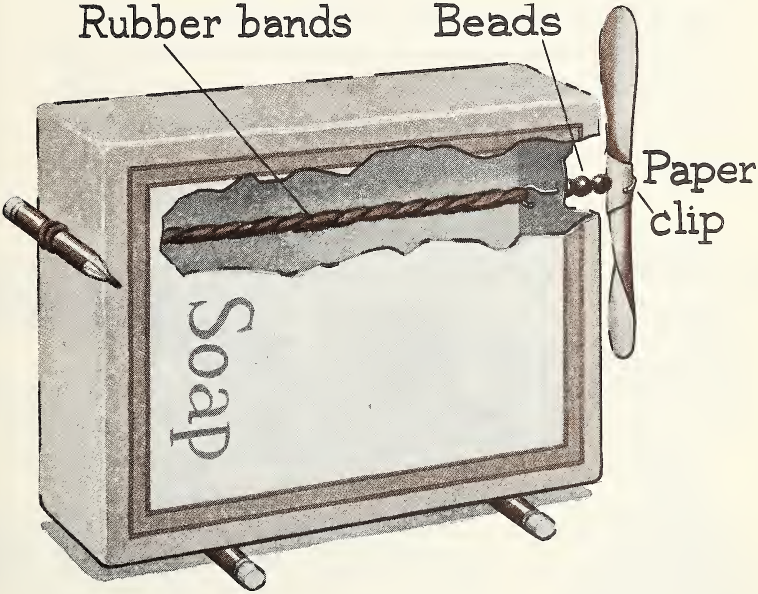
Carefully roll the propeller around a pencil to shape it. Roll it until the three holes come together. As you can see in the picture below, one edge of each blade is curved and the other edge is flat.

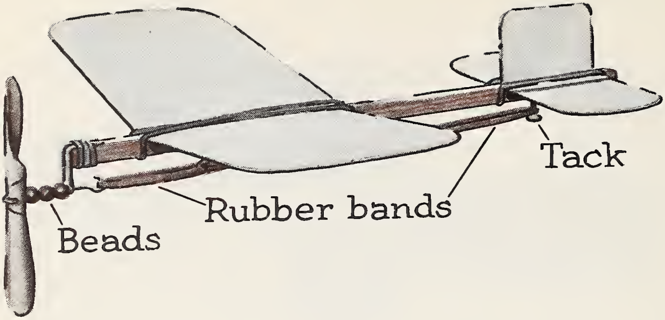


Straighten out a paper clip for the propeller shaft. Push it through the three holes in the propeller. Find three glass beads and slip them on the wire for bearings. Bend one end of the wire around the propeller. Bend a hook in the other end of the wire.

Make a small hole in the end of a soap box and push the propeller shaft through it. Slip three rubber bands over a pencil and hook them to the propeller shaft.

Set the box on some round pencils. Wind up the propeller and then let it go.

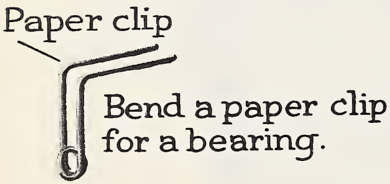




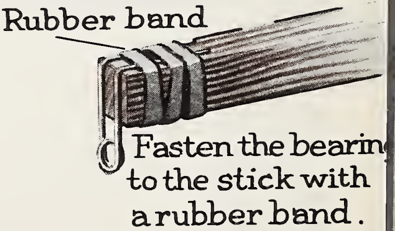
## A Flying Model

This flying model will help you understand more about how airplanes fly. It uses the propeller and the rubber band motor that you just made.

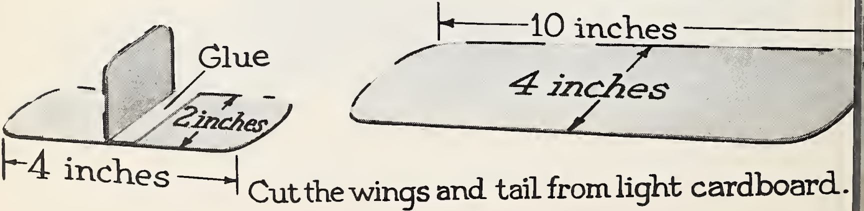
You will need a stick of balsa wood 12 inches long and one-fourth inch square. Balsa wood is very light. You can buy it in stores that sell things for making models.



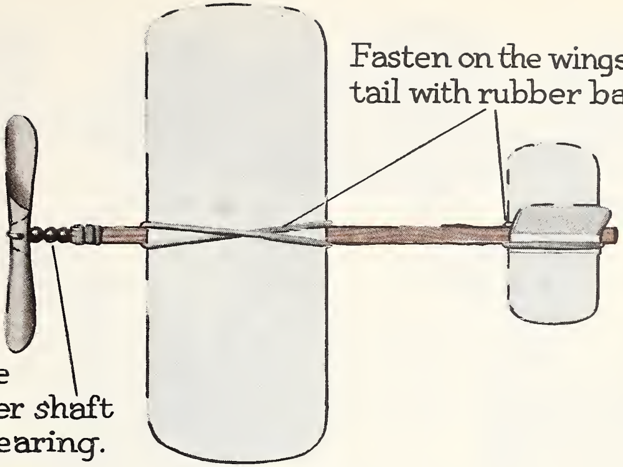
Bend a paper clip for a bearing.



Fasten the bearin
to the stick with
a rubber band.



Cut the wings and tail from light cardboard.



Fasten on the wings and tail with rubber bands.

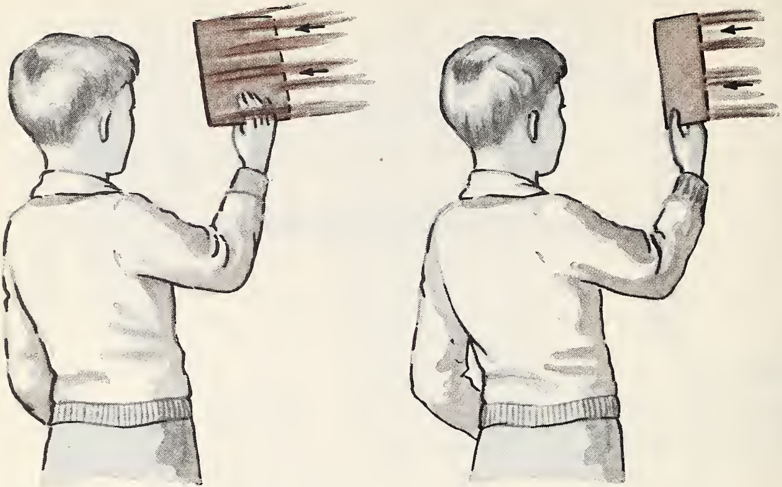
Slip the propeller shaft in the bearing.

Put the model together as shown on these two pages. Be sure that the wings are slanted as shown at the top of page 242.

Turn the propeller backward about 100 turns with your finger. Give the plane a gentle push forward and let it go.

If the plane noses up or down too much, move the wings backward or forward a little.

You can buy kits for making other kinds of model planes. Some of them help you to make wings that have more lift than the flat wings on this model have.

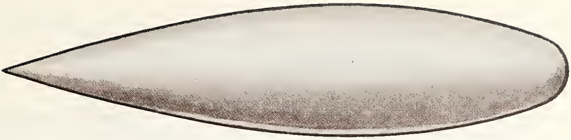


## Air Resistance

Wave a piece of cardboard with its flat side to the front. Notice the air resistance. Then wave the cardboard with its edge to the front. Notice the difference.

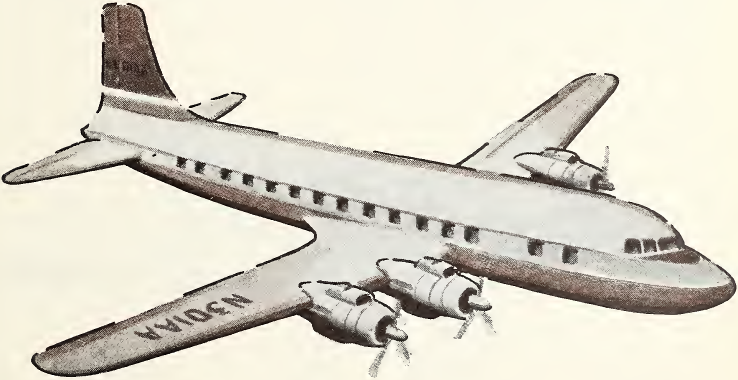
There is always air resistance when you move anything through the air. This is because you must push the air out of the way. When you waved the cardboard, you had to move much air the first time and only a little air the second time.

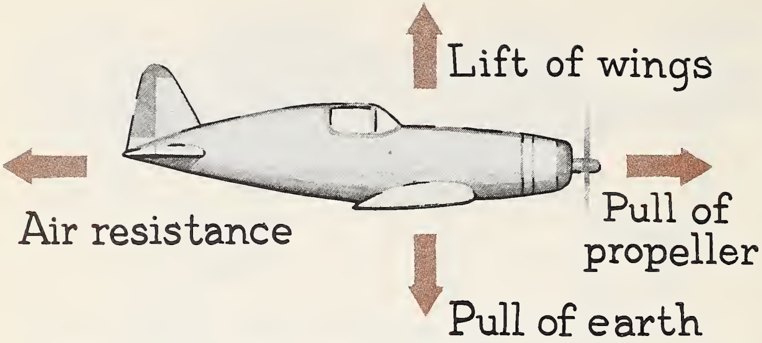
Try moving the cardboard rapidly and then again slowly. Which way makes more air resistance? Have you noticed any differences in air resistance when you rode on a bicycle?



Air resistance can be very great when airplanes move hundreds of miles an hour. Men who plan airplanes try countless experiments to find ways of keeping air resistance as small as possible.

Experiments have shown that the best shape is that shown above. Study the pictures of airplanes and notice how close the planes come to this shape. What did the builders do with the motors, the wings, and the tail to keep air resistance low? What did they do with the landing wheels?

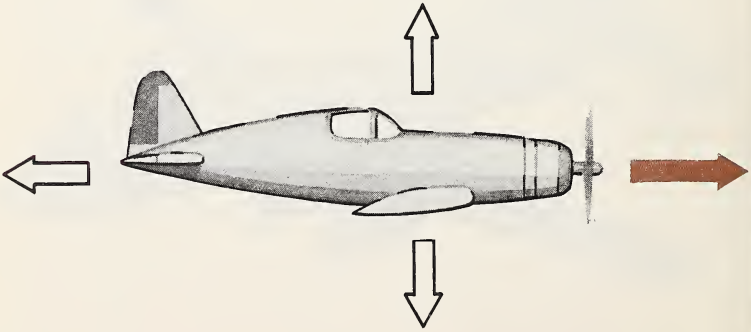


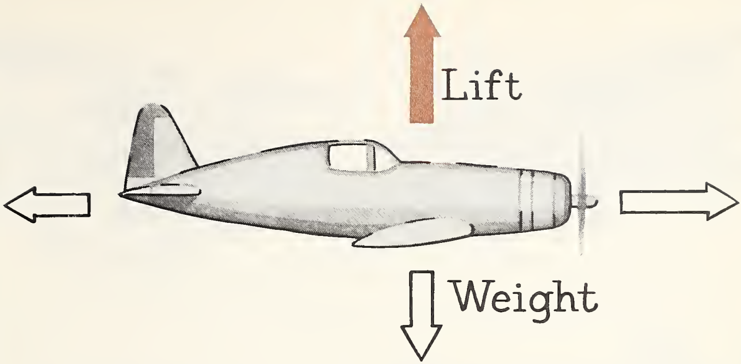


## Forces on an Airplane

There are four big forces that act on an airplane. The earth pulls downward on an airplane. The wings lift the plane. The propeller pulls it forward. Air resistance holds it back.

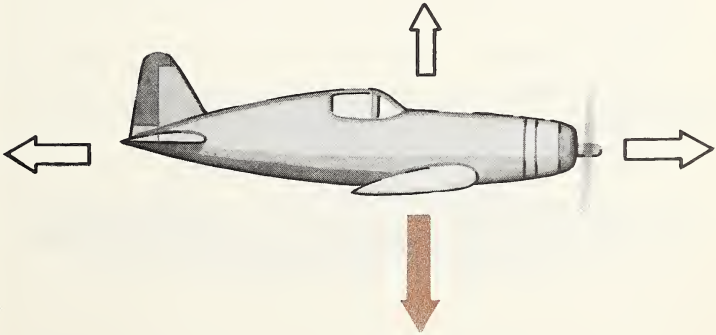
The diagram below shows a plane just after the pilot made the engine turn faster. The pull of the propeller is now greater than the air resistance. The airplane will begin to move faster.

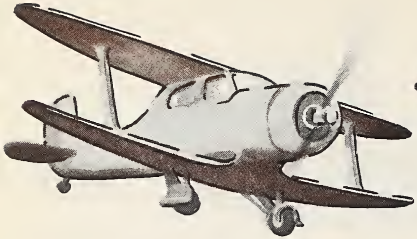


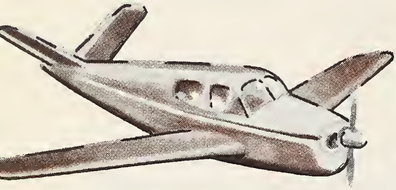


In the upper diagram on this page, the lift of the wings is greater because the airplane is going faster. The plane will now rise. When a pilot takes off from an airfield, he wants the airplane to go as fast as it can so the lift will be much greater than the weight.

In the diagram below, the lift of the wings is small because the airplane is going slowly. The lift is less than the weight. The plane will drop slowly as it moves along.





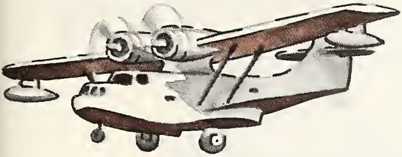


## Kinds of Airplanes

People have experimented with many different kinds of planes. No one plane has been discovered to be perfect for every use. Some kinds are cheap to build, but they cannot carry heavy loads. Some kinds fly very fast, but they need long runways for landing and taking off.

Visit an airfield and study some different kinds of airplanes. Bring pictures of other kinds of airplanes to school.

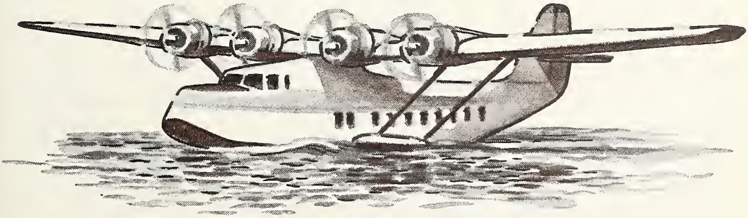
Notice where the wings are fastened. Notice the tail. Notice the number and kinds of engines. Look for ways the air resistance is kept as small as possible.

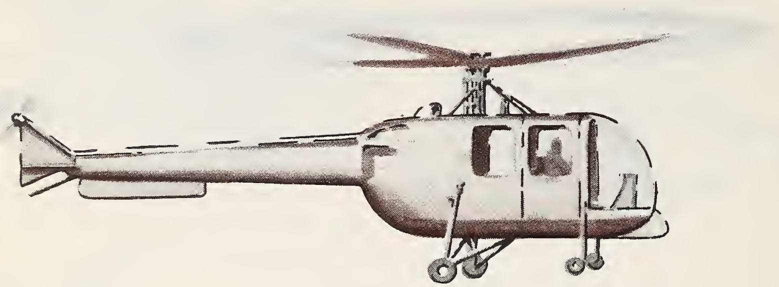


Most airplanes have landing wheels for landing on and taking off from the ground. Some airplanes, however, can land on and take off from the water.

Many of these planes are small. They have floats under the body and the wings. The bodies of the bigger planes are often built like boats. These planes can land and take off from large bodies of water where there are big waves.

There are uses for airplanes that can land on either the water or the ground. These planes have both floats and wheels. They are called amphibian planes.





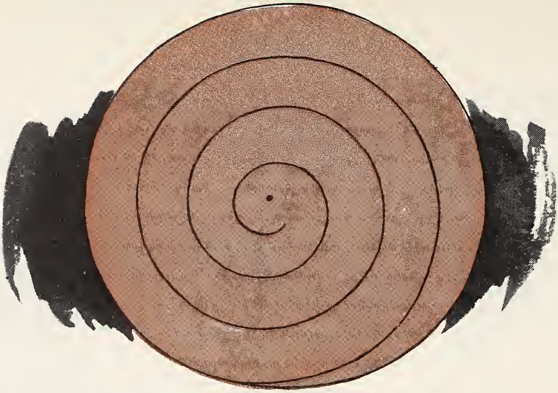
## Helicopters

A helicopter has wings that spin around, something like a propeller. When they spin rapidly, they pull the helicopter straight up. When they spin slowly, the helicopter sinks downward. There is also a small propeller on the tail that keeps the helicopter from turning around and around. How are helicopters used?

---

1. What causes the upward force on an airplane wing?
2. What does the propeller do?
3. What forces act on a plane while it is flying?
4. What makes a jet plane fly?
5. How does a pilot bank his plane as he makes a turn?
6. What are the elevators of an airplane used for?
7. How is the air resistance of a plane kept small?

# Warm Air in Motion

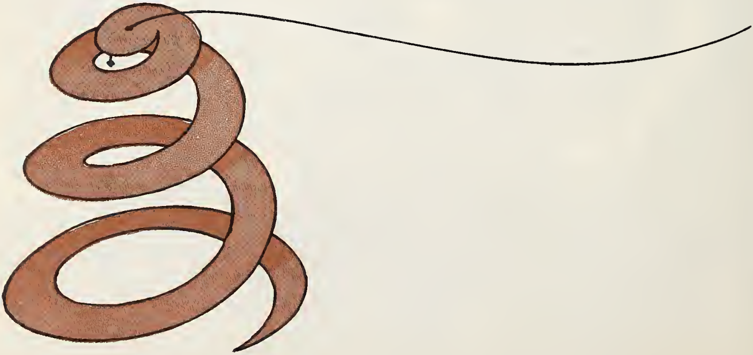


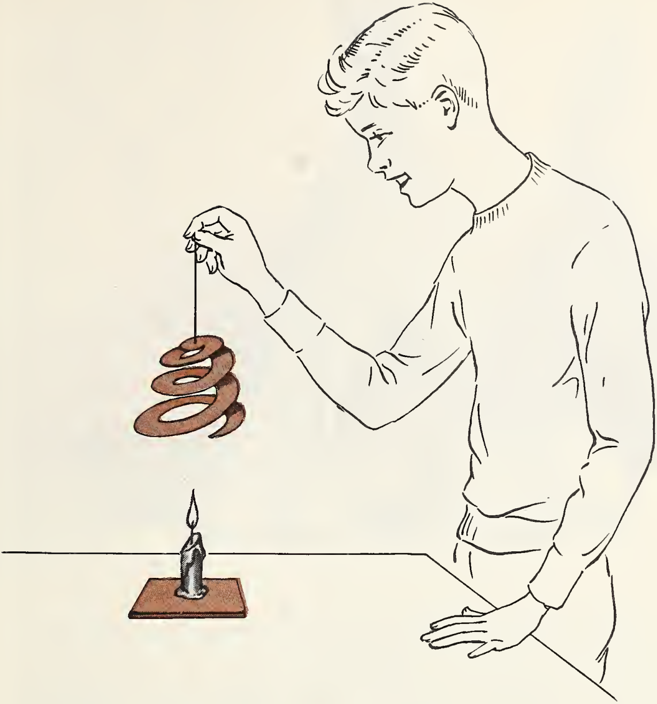
## A Whirling Spiral

Draw a spiral like this one on a sheet of heavy paper. Cut along the line from the outside to the centre. Push a knotted thread through the centre hole.

Lift the spiral by the thread. It should spread out evenly like the one in the picture below. If it does not hang evenly, you may have made the lines too close together or too far apart. Try again until you have a good spiral.

Hold the spiral over your head and blow through it. The spiral should turn as the air moves up through it.





Hold the spiral over an unlighted candle. Then hold it over a lighted candle, being careful not to let the paper come too close to the flame.

Hold the spiral over an electric hot plate. Turn on the electricity and notice what happens as the hot plate becomes heated.

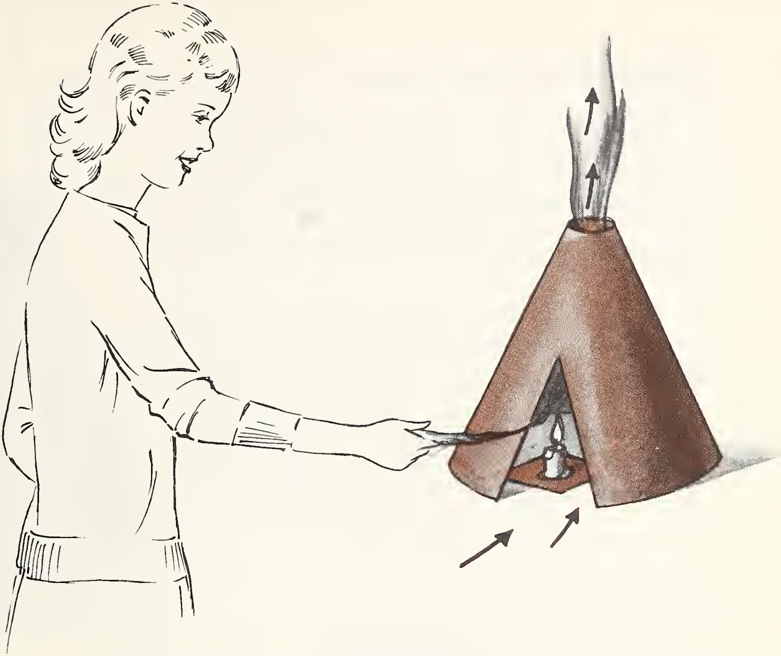
The spiral spins when it is in heated air. It is turned by the rising air.

## Warm Air in a Tepee

Indians who live in tepees know how air moves when it is warmed. They build their fire in the centre of a tepee. They leave an opening at the top for the smoke to go out.

Cold air comes in around the bottom of the tepee. The air is warmed by the fire and rises, taking the smoke with it. This smoky warm air goes out the top of the tepee.

Indians usually sit or squat in a tepee while a fire is burning. The air near the ground has less smoke in it than the air higher up.

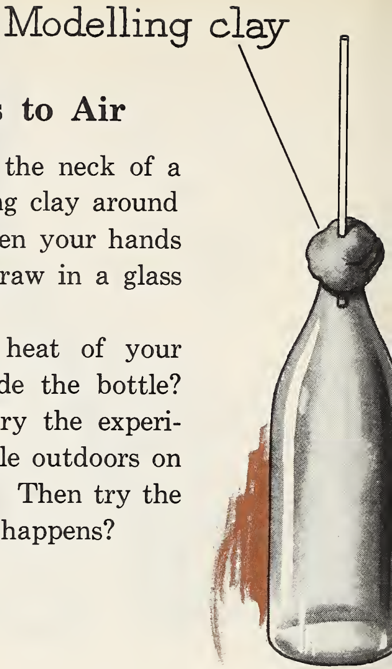


Make a little tepee from a sheet of paper and some sticky tape. Use a very short candle in the tepee for the fire. Keep the candle in the middle of the tepee so that there is less danger from fire.

Hold your hand over the tepee. Can you feel warm air coming out?

Roll up a sheet of tissue paper. Light the paper, let it burn a few seconds, and then blow out the flame. The tissue will give off smoke.

Hold the smoking paper near the opening at the bottom of the tepee. Where does the smoke go? Is the air smoky inside the tepee? Describe the path of the air in the tepee.



## What Heating Does to Air

Fasten a soda straw in the neck of a bottle by pressing modelling clay around it. Hold the bottle between your hands and put the end of the straw in a glass of water.

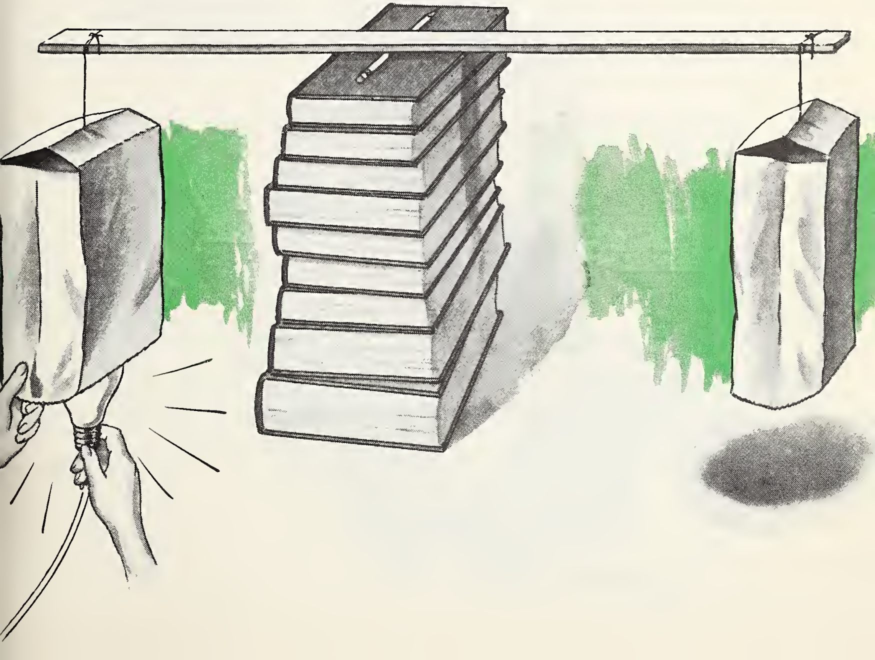
What happens as the heat of your hands warms the air inside the bottle? Let the bottle cool and try the experiment again. Put the bottle outdoors on a cold day until it is cold. Then try the experiment again. What happens?

Open two paper bags, turn them upside down, and tie them to the ends of a yardstick. Balance the yardstick on a round pencil.

Heat the air in one of the bags with an electric lamp or a candle flame. You must hold the bag with one hand so that it will not be pushed upward by the rising air.

After a few moments of heating, take away the lamp and let go of the bag. What happens? What happens after the bag cools again?

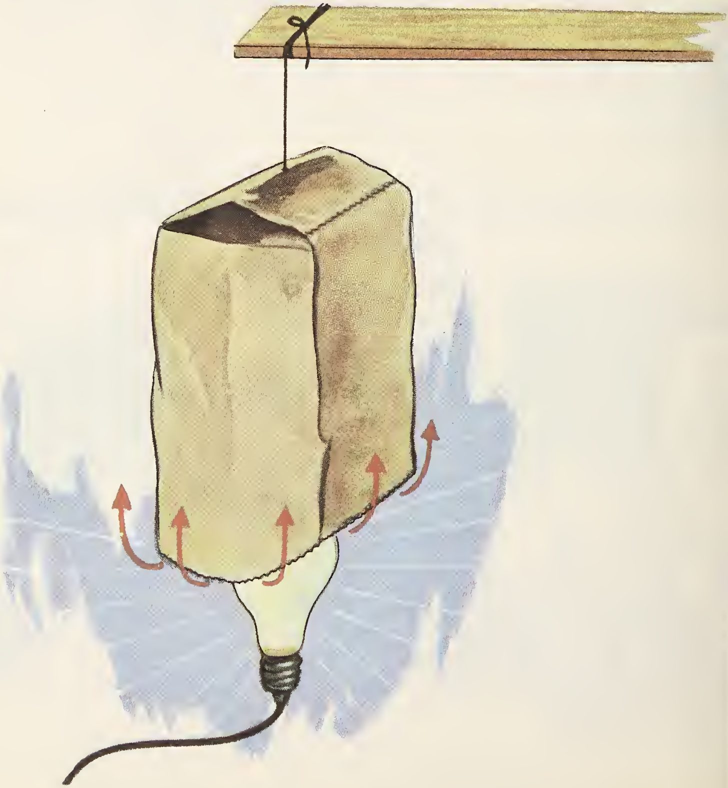
Try the experiment several times, heating first one bag and then the other. Which seems to be heavier, a bag of warm air or a bag of cool air?

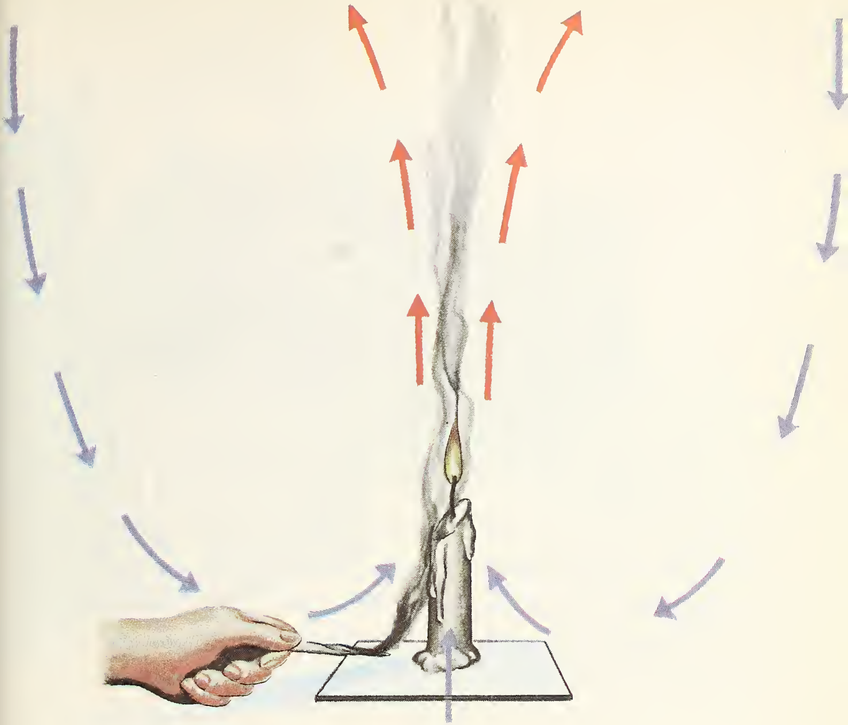


## Why Heated Air Rises

Your experiments have shown that air expands and thus takes up more space as it is heated. Let us study the last experiment to see why the air becomes lighter when it is heated.

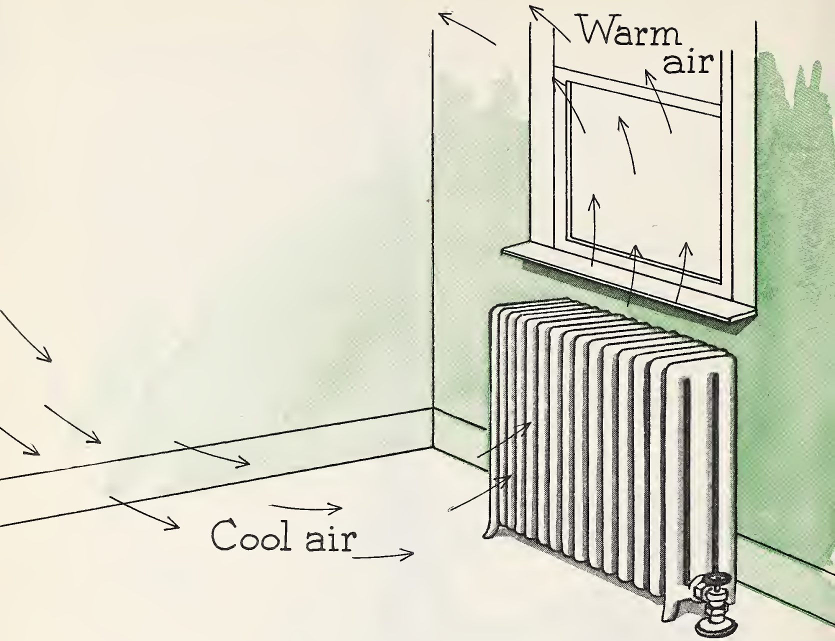
At the beginning of the experiment, the air in both bags has the same temperature and both bags weigh the same. When you heated the air in one bag, the air expanded and some of it left the bag. This bag then weighed less than the other because there was less air in it.





Air around a candle rises for the same reason the bag of warm air rose in the last experiment. The air over the candle flame is heated and expands. This air then weighs less than the cool air around it. In other words, the earth pulls harder on cool air than it does on warm air.

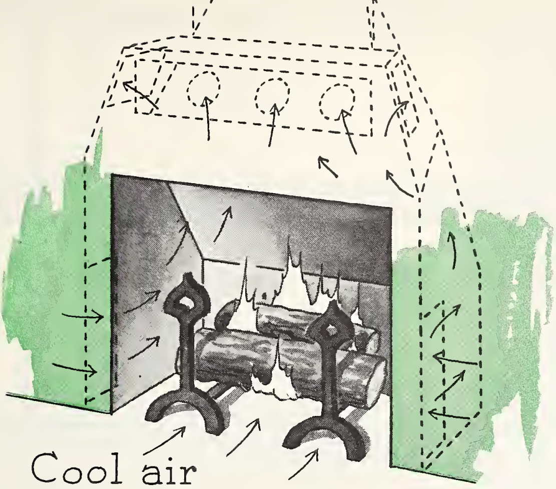
The cool air moves down and pushes the warm air up out of its way. Some of the cool air near the flame is now heated and is pushed up in its turn. A steady flow of air is set up.



## Using the Movement of Heated Air

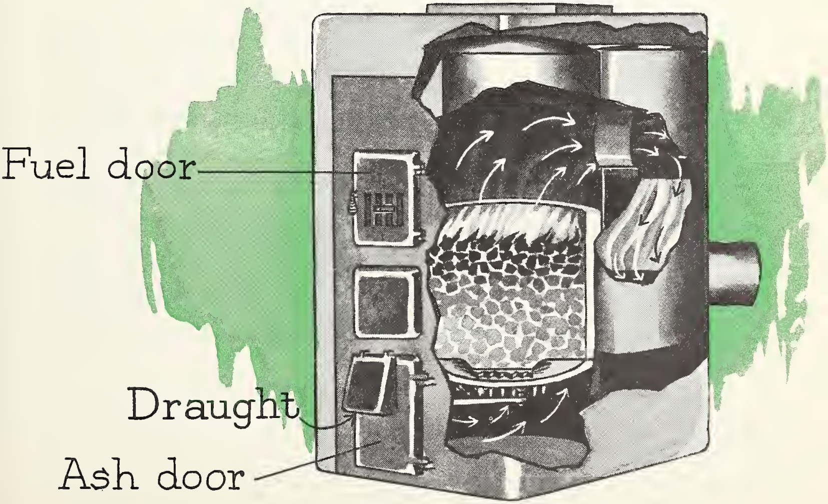
A radiator on one side of a room can heat other parts of a room. Air near the radiator is warmed and expands. Cool air above it moves down and pushes the warm air up. Tell what happens next.

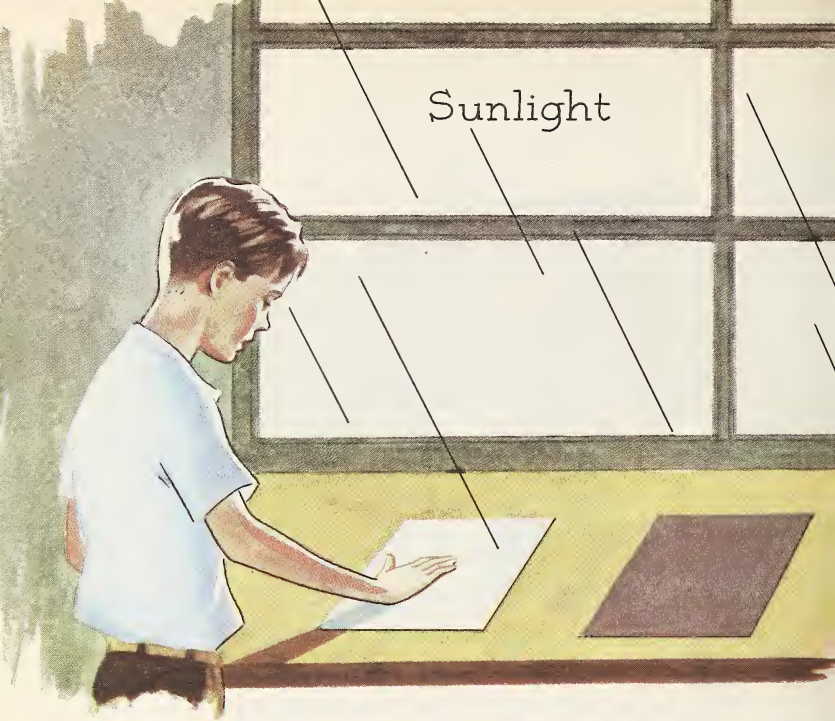
Where would you expect the warmest place in the room to be? Where would you expect to find the coolest air? Hang thermometers in different parts of the room and find the temperatures of the air in these places.



Warm air inside a chimney weighs less than cool air outdoors. The cool air enters the house through cracks and keyholes and pushes the warm air up the chimney. Why does this make the fire burn more brightly?

Can you explain why there is a draught in a stove or furnace?





## Unequal Heating of Surfaces

Lay a sheet of dark paper and a sheet of white paper on a sunny window sill. After a few minutes, touch the dark paper and the white paper. Which feels warmer?

Try the experiment with dark cloth and white cloth. Try it with white sand and dark sand.

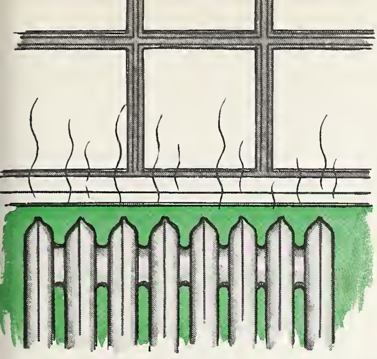
Sunlight warms things it falls upon. The white paper reflects much of the sunlight. The dark paper changes much of the sunlight into heat.

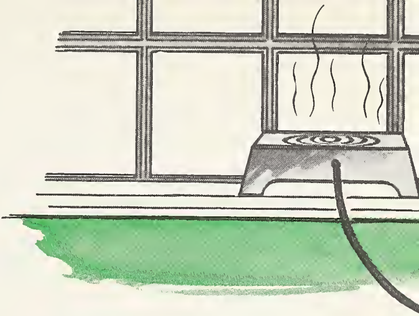
Set a dish of water and a dish of dry soil on a sunny window sill. After half an hour, hold your hand over the soil and then over the water. Which seems warmer?

Water does not heat up so rapidly as soil when sunlight falls on it. More of the sunlight is reflected from the water. The water also needs more energy than soil needs to make it change temperature.

Go outdoors on a sunny day and touch different things. Touch the shiny parts of an automobile and the painted parts. Which parts are hotter, or are they both the same?

Does a concrete walk or the grass growing beside it seem to be the hotter? Does bare ground or grass-covered ground become hotter?

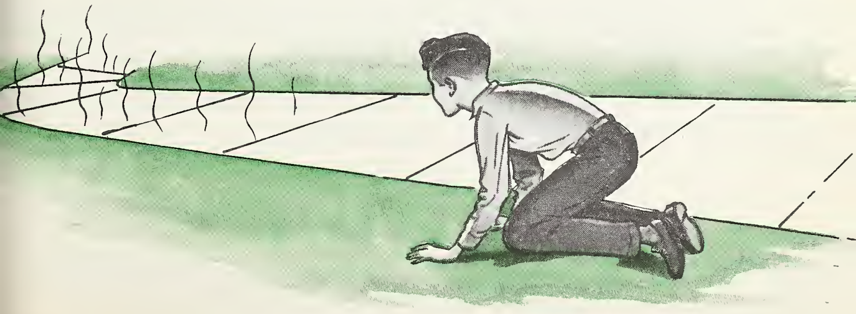


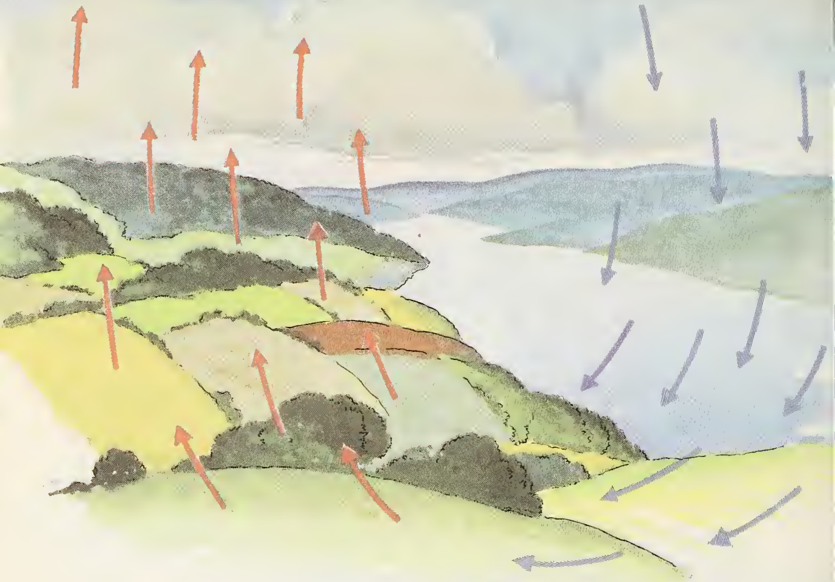


Look at a heated radiator or a hot plate that is in sunlight. Notice how things beyond them seem to dance about. Place a lighted candle in sunlight and notice its shadow. Notice that there are wavy lines around the flame.

Light bends when it enters and leaves warm air just as it bends when it enters and leaves glass. Air over something hot becomes heated and rises. Light going through this rising air is bent more or less as the air moves about.

You can see somewhat the same thing outdoors on a hot sunny day. The sunlight heats solid things like sidewalks and roads. The air next to the solid things is heated and rises. When you look through the heated air, things seem to dance and wave about.

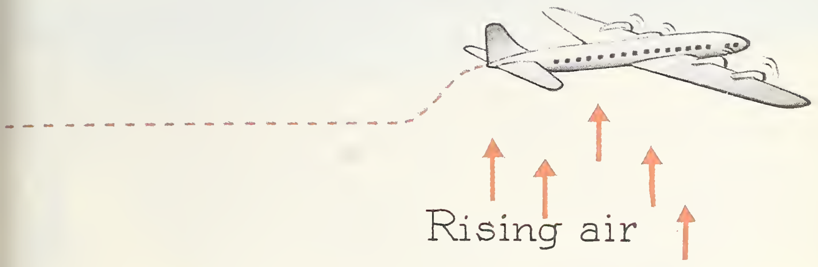




## Rising and Falling Air Currents

Sunshine heats land faster than it heats water. The air above land becomes warmer than the air above lakes. Cool air above lakes moves down toward the land and pushes the warm air up. You say that a breeze is blowing when you feel the air move from the cool places to the warm places.

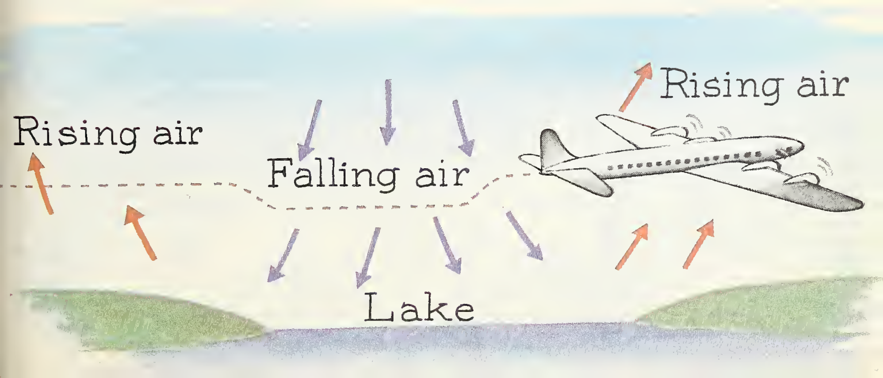
The sun does not heat all parts of the land equally. Rising and falling air currents are found over different kinds of fields. Which do you think is hotter on a sunny day, a bare field or a grass-covered field? Make up an experiment to test your answer.

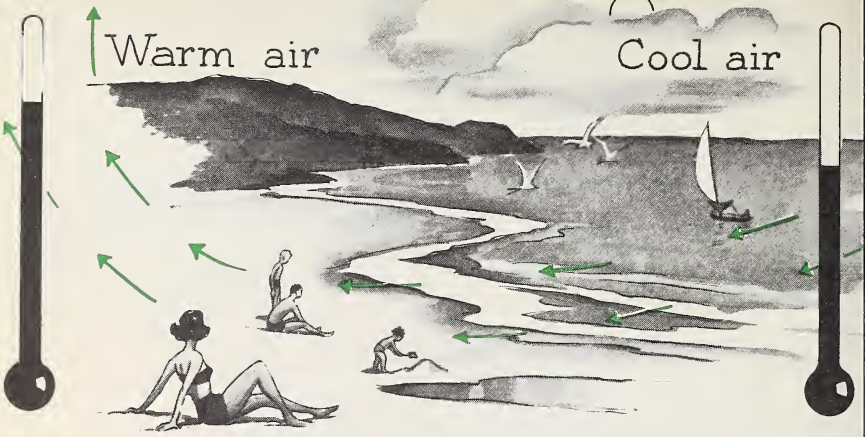


Airplane passengers often have bumpy rides on sunny afternoons. As a plane moves through rising air currents, it is raised a bit by each of them. As it moves through downward currents, it is carried downward a little.

Planes travel so fast they are not carried up and down very far by little currents of air. The planes are just shaken up a bit. If they enter large currents, they may be carried up or down a long way.

Flying is less bumpy high above the ground because the rising air currents cool off before they get very high. Airplanes fly above these currents as much as possible. Why do you think flying is less bumpy on cloudy days and at night than it is on sunny afternoons?

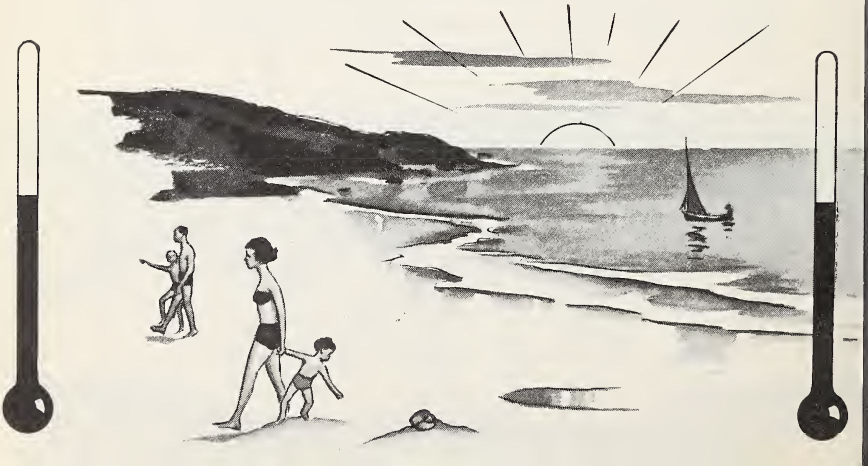


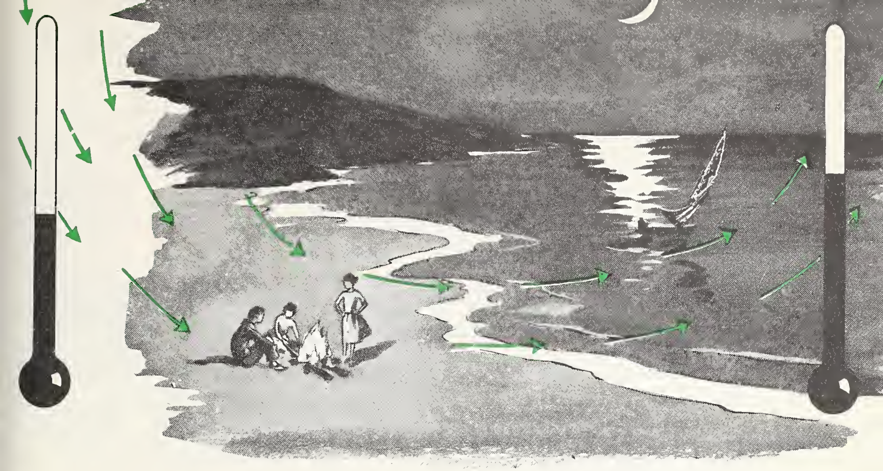


## Breezes Along the Shore

Your experiments have shown that soil heats up faster than water. Study the picture above and you will see why there is often a breeze blowing from the water toward the land on sunny afternoons in summer.

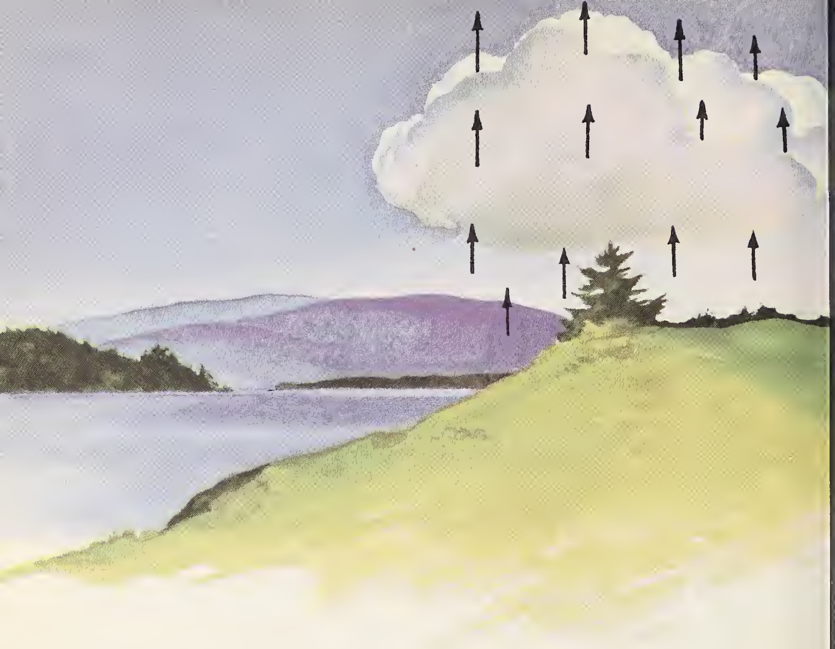
As the sun sets, the land cools quickly. The land soon becomes as cool as the water. Then the air over the land has the same temperature as the air over the water. The breeze stops blowing.





During the night, the land may become cooler than the water. The air over the land then becomes cool, too. Cool air from the land moves over the shore and pushes up the warmer air over the water.

When morning comes, the sun warms the land again. When the air over the land has the same temperature as the air over the water, the breeze stops again. Notice the way the breezes blow next summer if you go to the shore of the ocean or a large lake.

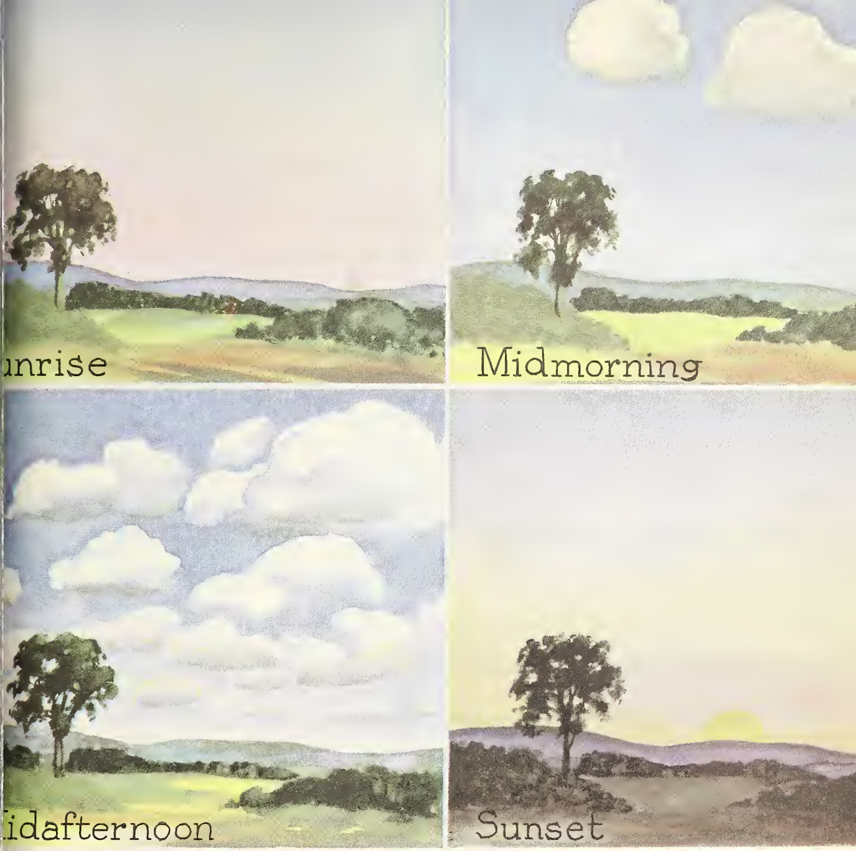


## Rising Air and Clouds

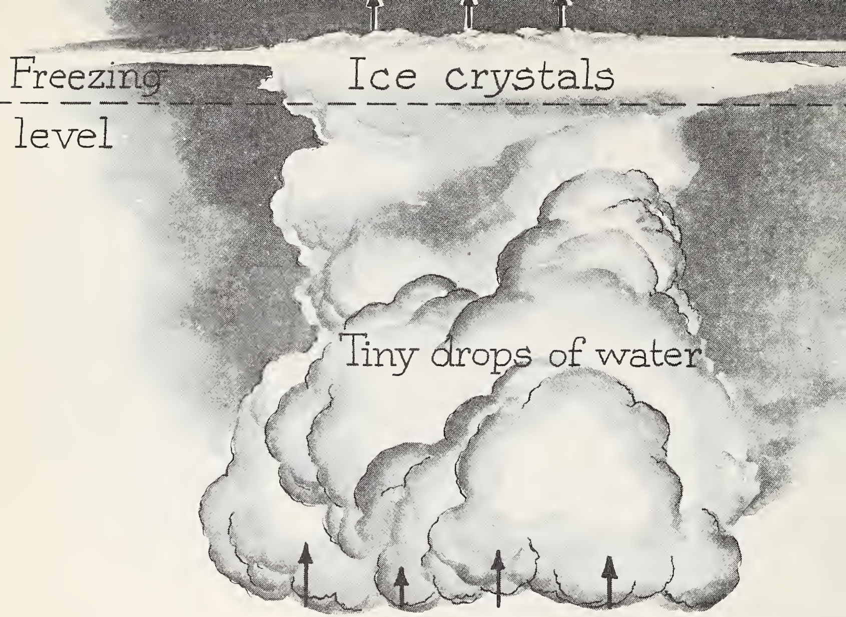
Rising air cools as it goes up. Sometimes it holds much water vapour. The water vapour condenses into tiny drops of water as the air cools.

Cumulus clouds form in this way. The bottom of a cumulus cloud shows where the air is cold enough to make the water vapour condense.

Look for cumulus clouds on sunny days. Imagine that you can see the rising air currents that make the clouds. If you were an airplane pilot, what would you expect to happen as you flew under a cumulus cloud?



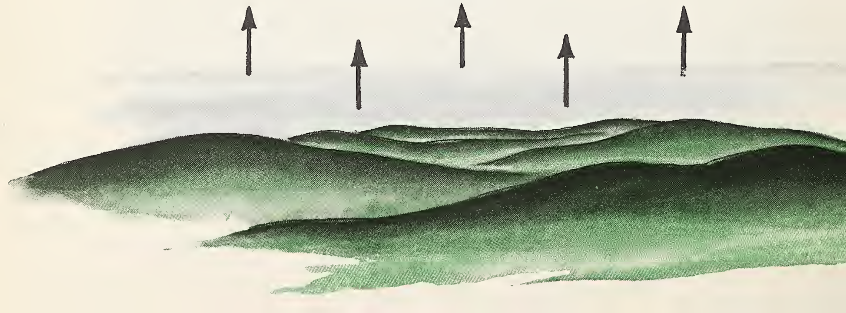
Perhaps you have known days like this one. Cumulus clouds begin to form in the late morning after the land heats up in sunlight. As more warm air rises during the hot afternoon, there are more and larger clouds. When the soil cools again near sunset, warm air stops rising, the cumulus clouds evaporate, and the sky is clear again.

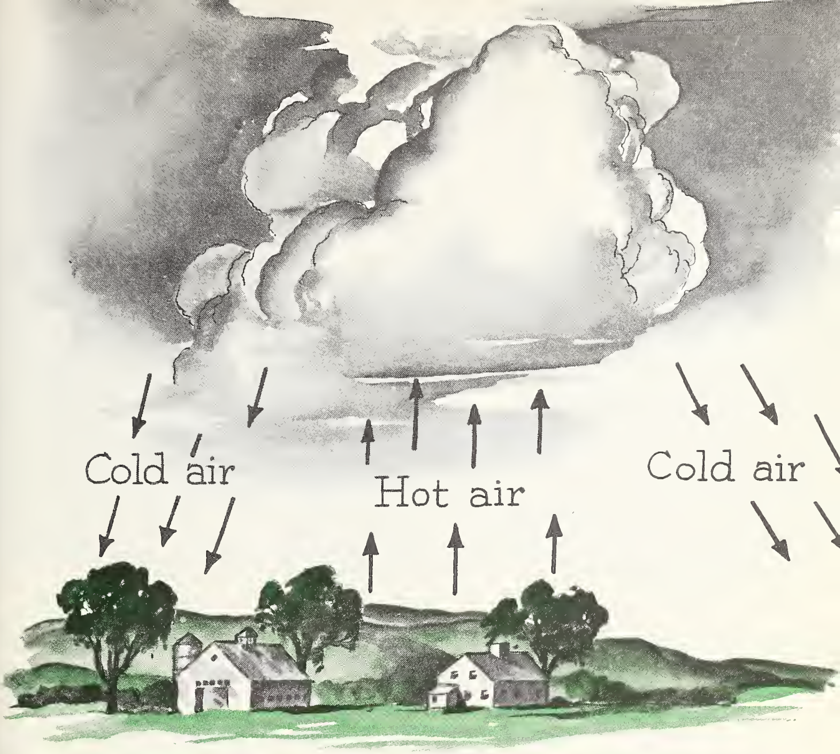


## Thunderstorms

Thunderstorms are most common on hot afternoons in summer. The air is often hot and moist on such afternoons. Rising air currents build up tall cumulus clouds.

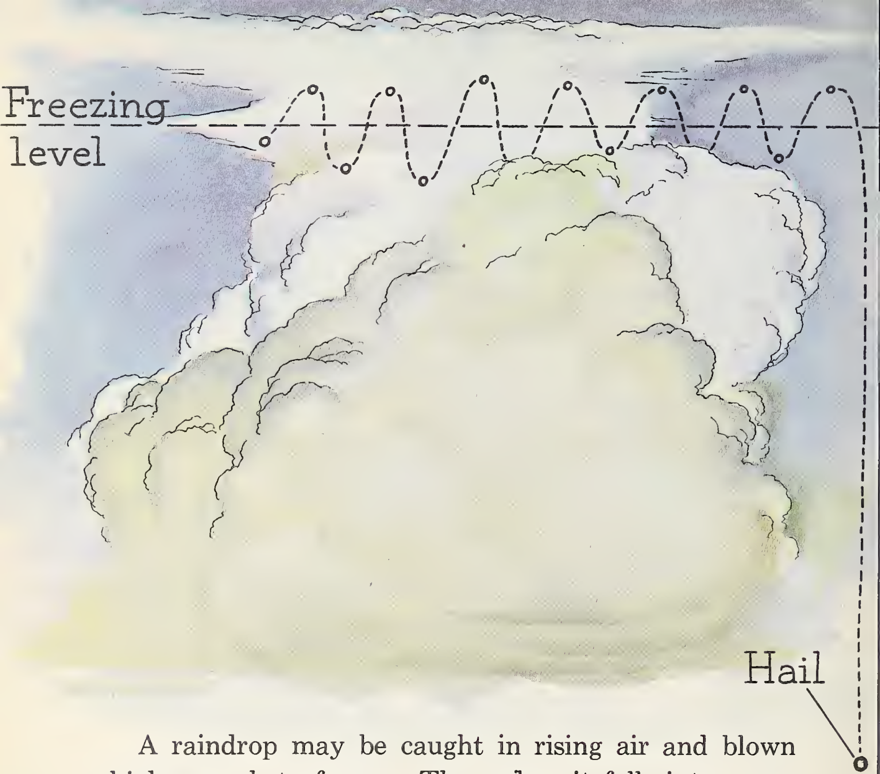
The tops of these big clouds may be so high that they are above the freezing level. The tops of such clouds are made up of ice crystals. We call these big clouds "thunderheads."





The rising air currents that make a thunderhead may move faster and faster. Sometimes they may rise faster than a hundred miles an hour. At the same time, the storm begins to move across the country.

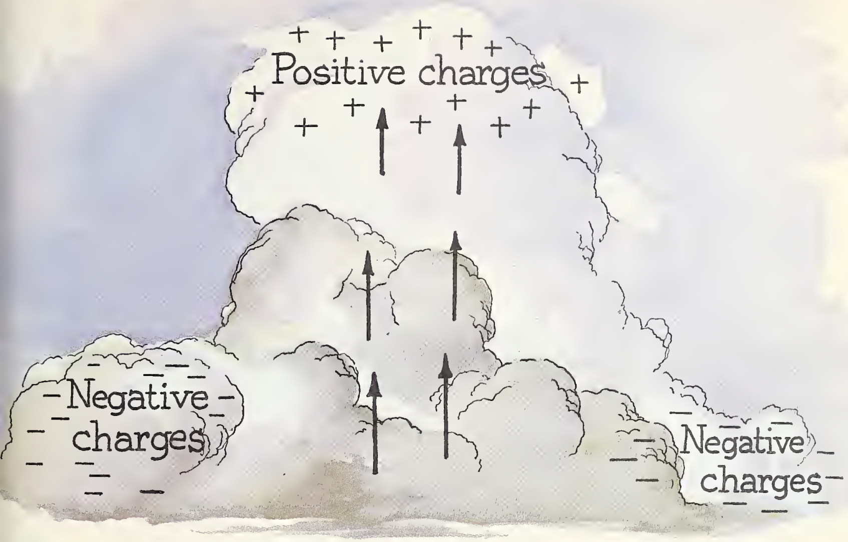
Ice crystals from the tops of the clouds are blown down into the warm air beneath. Water vapour condenses on these cold crystals. They may become big enough to fall. Sometimes the drops are caught in currents of falling air and blown against the ground with great force.



A raindrop may be caught in rising air and blown high enough to freeze. Then when it falls into warm moist air again, water vapour condenses on it and makes it bigger. If the drop is blown up above the freezing level several times, it may become a large hailstone.

Hail is sometimes blown to the ground with great force. A hail storm may break windows, dent automobiles, knock fruit from trees, and cut off garden plants.

If a hailstone is cut open, it usually shows the layers of ice that were formed as it was blown up and down in the thunderhead.



We believe that electric charges are formed when raindrops are blown apart by swift air currents in a thunderhead. One kind of charge is formed on the smaller parts of the raindrops. The other kind of charge is formed on the larger parts of the raindrops.

The smaller parts are carried higher than the larger parts. Soon the top of the thunderhead has many charges of one kind, and other parts of the cloud have charges of the other kind. A spark jumps from one part of the cloud to another. Sometimes a spark jumps from one part of the cloud to the ground.

This spark which we call lightning heats the air around it. The air expands suddenly and sends out vibrations in all directions. The vibrations cause the sound we call thunder.

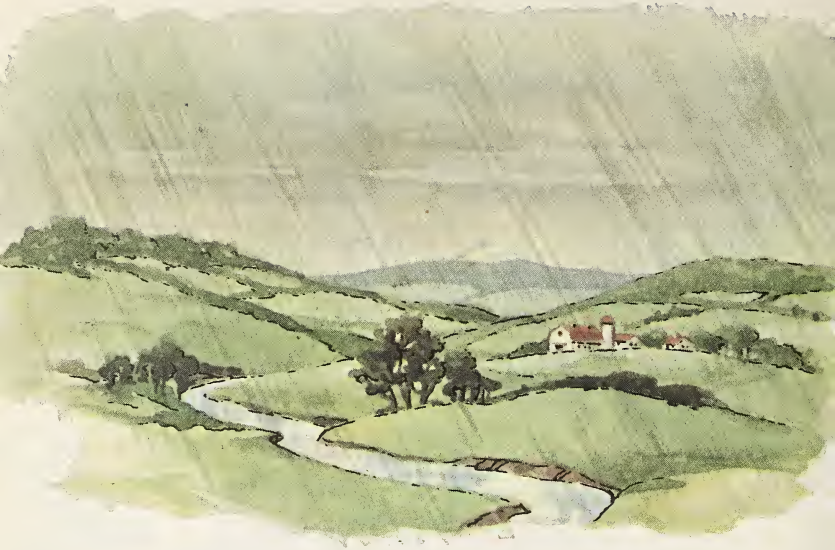
## Tornadoes

Rapidly rising air currents may begin to spin as they rise. They spin faster and faster until the wind may go over 500 miles an hour. If one of these storms passes over buildings and crops it does great damage. Fortunately, these storms are small and do not last long. They are not common in most parts of the country.

---

1. What happens to air when it is heated?
2. Why does heated air rise when it is free to do so?
3. Where can you find heated air moving in homes?
4. Where might a pilot expect to find rapidly rising currents of air?
5. How are cumulus clouds formed?
6. What is a thunderhead?
7. Why is there often a breeze at the shore on sunny days in summer?

# Water in the Ground

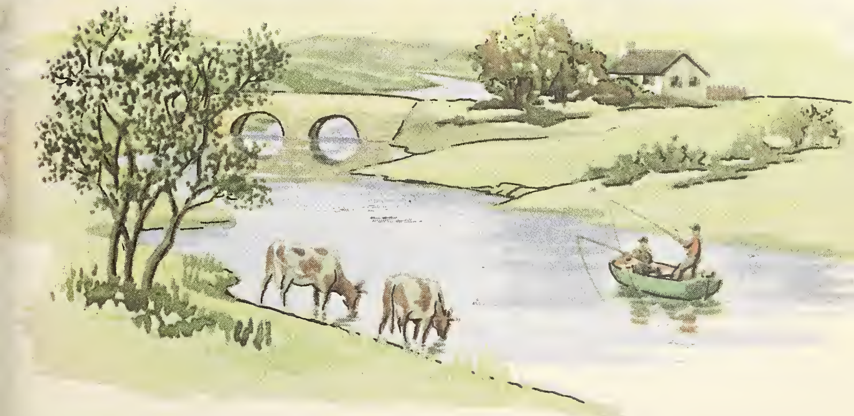


## Where Rain Water Goes

Thousands of gallons of water may fall on a field during one rain storm. Part of this water evaporates into the air again. Part of it runs away in streams. The rest of the water soaks into the soil.

The water that evaporates is gone. It has done us little good. The water that runs away is also gone. If it runs away too rapidly, it may do harm by carrying away soil and perhaps causing floods.

The water that soaks into the ground is useful. Plants use it. People and animals drink it from springs and wells. The water that is left flows slowly from springs into streams where it keeps fish alive, turns water wheels, and floats boats.

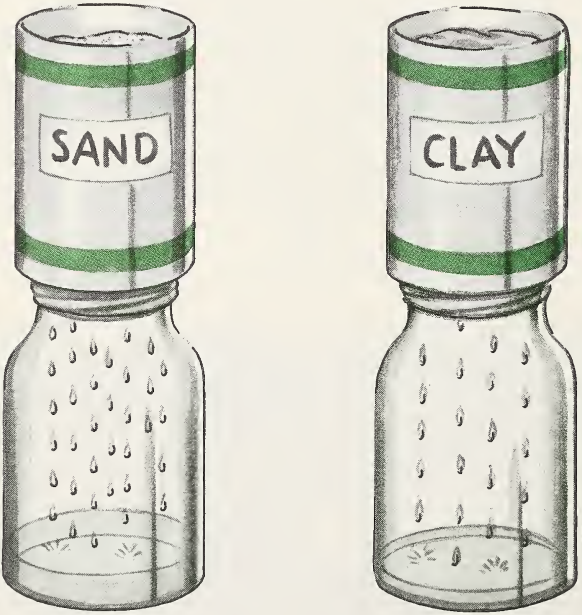


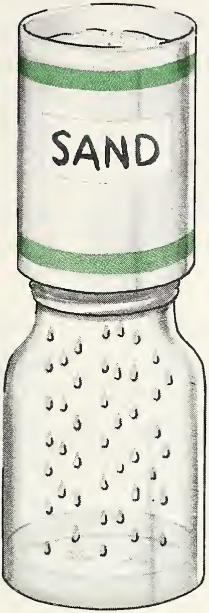
## Testing Soil Drainage

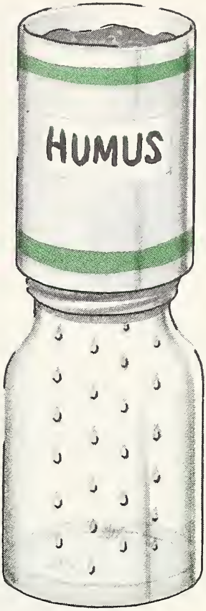
Water passes through some kinds of soil more rapidly than through other kinds of soil.

Punch several small nail holes in the bottoms of two metal cans. Fill one can about three-quarters full with dry sand and the other with dry clay. Set the cans on glass jars.

Pour the same amount of water into each can. Which soil lets the water go through faster? Try other kinds of soil.







This experiment shows the effect of decayed plants on the moisture in soil. Fill one of the two cans with dry humus from the woods or with dry peat moss. Fill the other can with dry sand.

Pour the same amount of water into each can. What happens? Does humus help soil hold more or less water? How do forests help keep water in the soil?

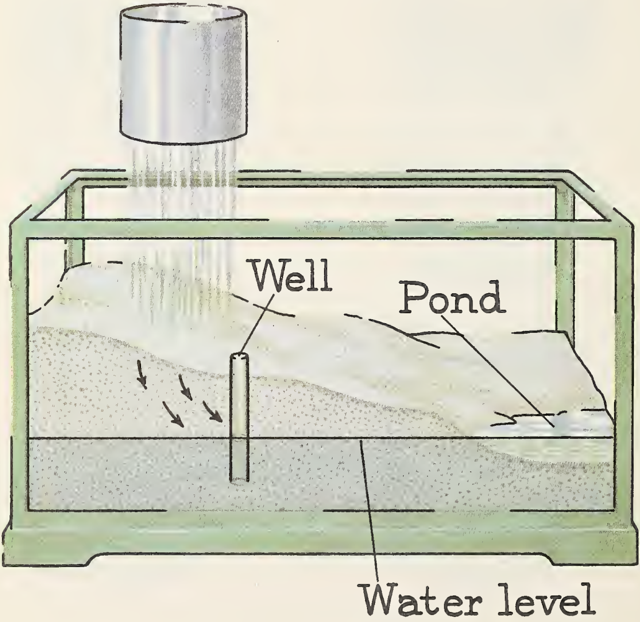
## The Water Level in Soil

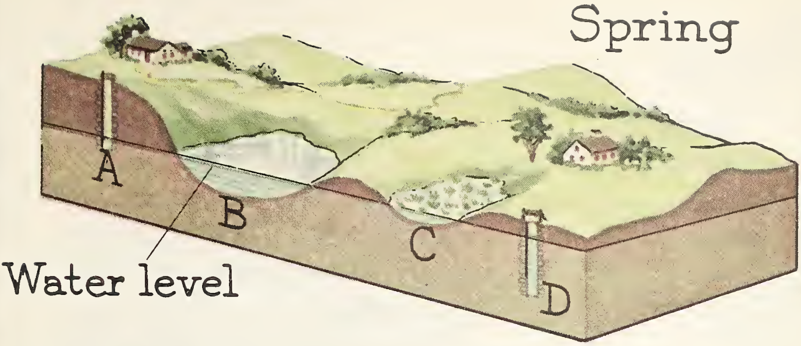
Water that goes into soil may fill the spaces in the soil. A model will show how this happens.

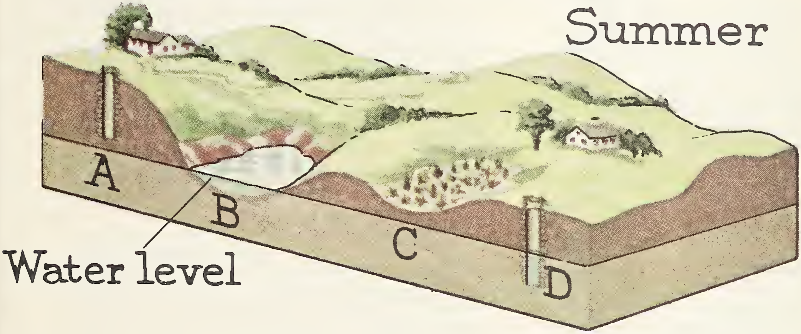
Put sand in an aquarium as shown in the picture. Sprinkle water on the sand. Watch it pass through the sand and fill up the spaces in the sand at the bottom.

Dig a well near one side of the aquarium using a stick. Put a glass tube in the hole. Now you can see how water goes into a well.

Some of the water will evaporate from the sand during the next few days. Notice that the water level becomes lower in the sand and in the well. Another sprinkling will bring it back to the first level.







These pictures show the same piece of land during a wet season and during a dry season.

The pond at B grows smaller when there is little rain. The marsh at C dries up in dry weather but it fills up after heavy rains. Have you seen any ponds and marshes that dry up when there is little rain?

The well at D has water in it in both wet weather and in dry weather. The well at A may dry up in dry weather.

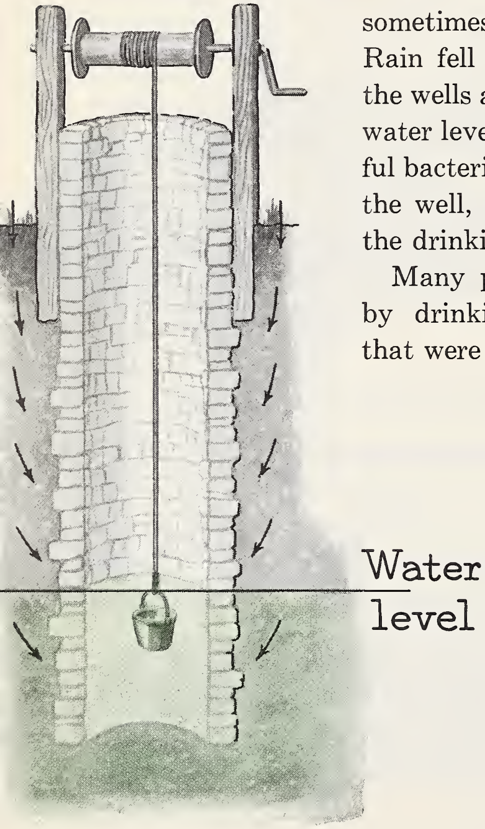
## Wells

Early wells were dug out by hand. The sides were built up with stones.

Such wells were not deep and they did not go far below the water level in the soil. There might be plenty of water in these wells in wet seasons, but they often became dry in dry seasons.

The water in these wells was sometimes unsafe for drinking. Rain fell on the ground around the wells and soaked down to the water level. If there were harmful bacteria in the ground around the well, they were carried into the drinking water.

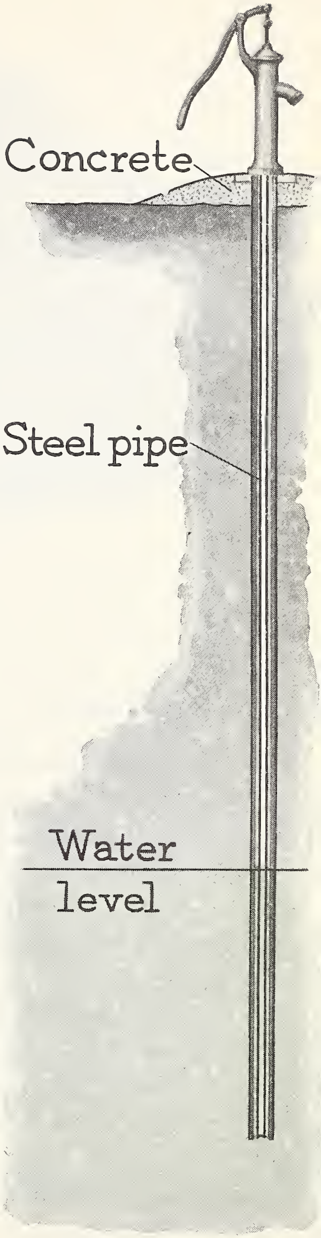
Many people were made sick by drinking water from wells that were not safe.

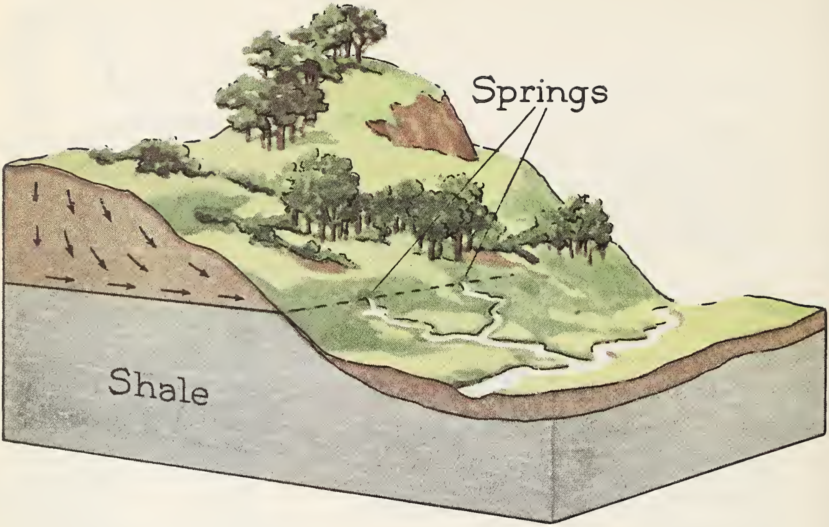


Today, most wells are drilled by machinery. The wells are deep and often go through solid rock to layers that carry water. Find out how deep some of the new wells are around your home if you live in the country.

The wells are lined with steel pipe. Concrete is poured around the top to keep out dirty water. Such wells are usually safer than open wells.

We cannot be sure that the drinking water in any well is safe to drink unless we have it tested. The water may have come from a place where there are harmful bacteria. Health officers will test the water for you. They will tell you what to do if the water is not safe. They will tell you when to have the water tested again if it is safe to drink.



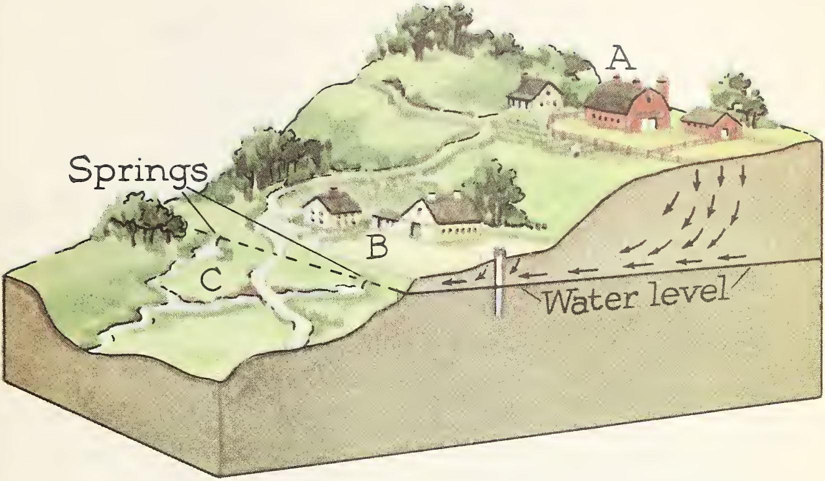


## Springs

Water that falls on a hill soaks into the soil until it comes to a layer that it cannot go through. Then it flows out the side of the hill in springs.

The water from the springs usually flows down the valley in a stream. Other streams run into it and make a bigger stream.

Sometimes the water cannot run away because of the shape of the land. There may be a swamp or marsh if the water is not deep. There may be a pond or lake if the water is deep.



Some people think the water in springs is safe to drink because it went through the soil. This is not so. Many people have been made sick by bacteria carried in ground water.

The rain that falls on the hill in the picture comes out of the springs at C. This water may have bacteria in it from the farms at A and B. The well at B may not be safe either, because some of the water may come from the farm at A.

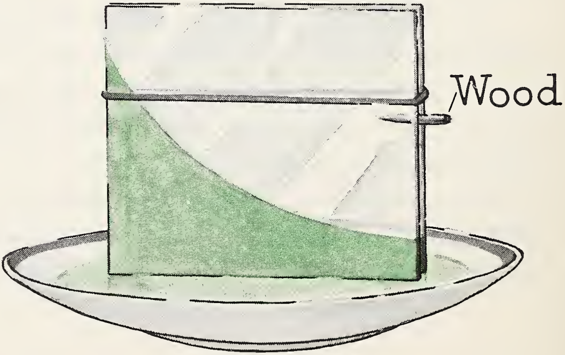
The only way to be sure that water in a spring or well is safe for drinking is to have it tested. If the water is not tested, boil the water before drinking it.

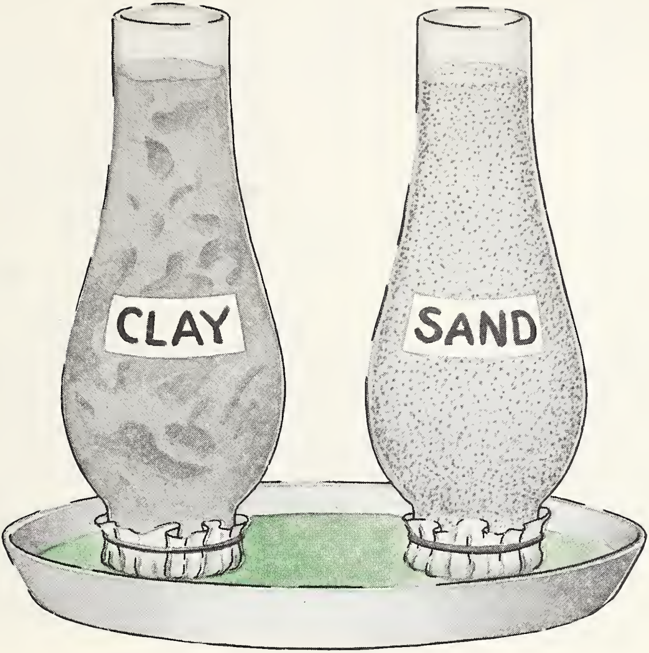
## Rise of Water in Soils

Rain that falls on soil moves downward because of the pull of the earth. In dry weather, some of this water may move upward again against the pull of the earth.

Put a piece of blotting paper in coloured water. There are many tiny spaces in blotting paper. Water is able to rise in these tiny spaces.

Slip a rubber band around two pieces of glass as shown in the picture below. Put a bit of wood between the pieces of glass to keep the edges apart at one side. Set the pieces of glass in a dish of coloured water. Where does the water climb the highest?





Water can rise in soil in much the same way. The water makes its way up through tiny spaces in the soil.

Test the speed with which water rises in different soils. Find two lamp chimneys. Tie a piece of paper towel on the bottom of each. Fill one chimney with dry clay. Fill the other with dry sand.

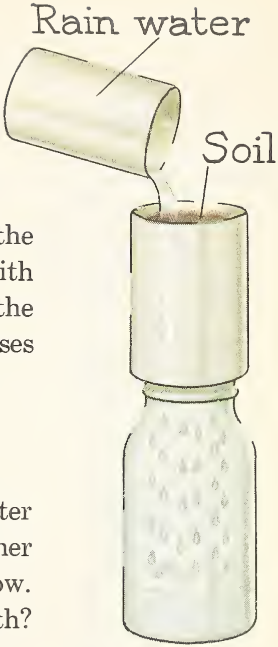
Set the chimneys in a tray. Put coloured water in the tray. In which kind of soil does the water rise higher?

## Minerals in Ground Water

The movement of water in soil is important to plants. During dry weather, water rises from the soaked soil far below the roots of plants. This water keeps plants alive.

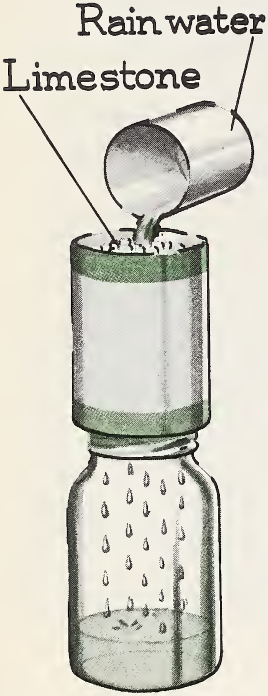
Many minerals in the soil dissolve in water. Plants need some of these minerals. Water that rises through the soil brings these minerals upward.

This experiment shows how important some of the dissolved minerals in ground water are to plants. Punch small nail holes in the bottom of a tin can. Fill the can with rich garden soil. Pour rain water on the soil and catch the water that passes through.



Put slips of house plants in this water that passed through the soil. Put other slips in rain water. Watch the slips grow. Which show the best root and leaf growth? Which are healthier after two weeks?

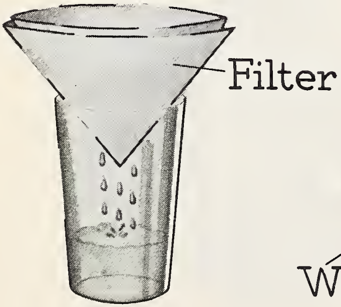
## Hard Water

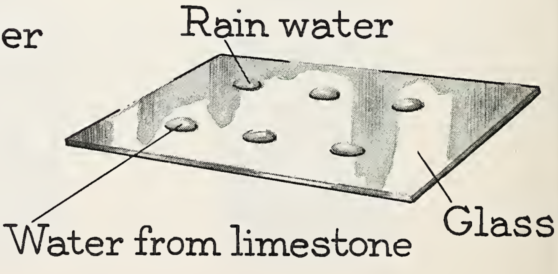


Limestone is a common rock in some parts of the country. Much of this rock was formed from shells and other parts of sea animals that lived long ago.

Some of the minerals in limestone dissolve easily in water. Put some pieces of limestone in a cloth bag and break them into small bits with a hammer. Put the bits of limestone into a can that has small holes in the bottom. Pour rain water into the can and catch the water that drips through. Pour this same water through the limestone several times.

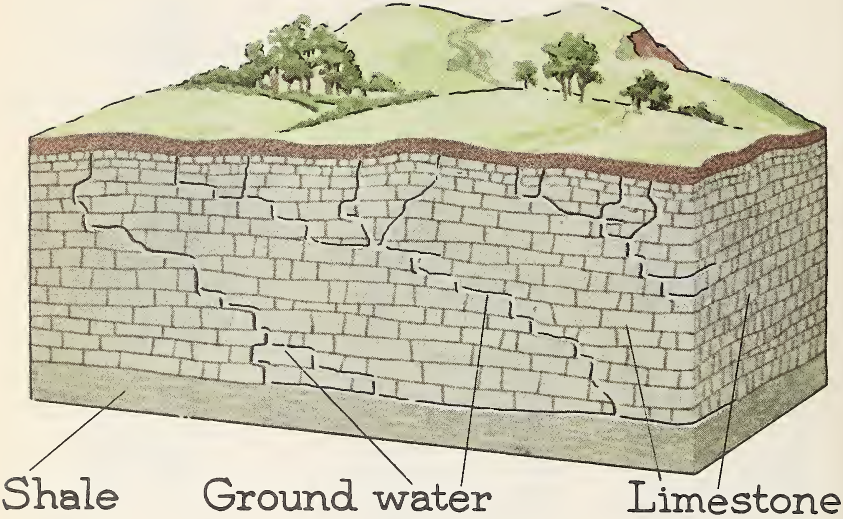
Filter the water through a piece of paper towel. Then put a few drops of the water on a pane of glass. Put a few drops of rain water on the glass. Let them evaporate. Is anything left on the glass?





Water that has minerals from rock such as limestone dissolved in it is called "hard water." Put some hard water in one bottle and some rain water in another bottle. Add the same amount of liquid soap to each bottle. Shake the bottles well. Which bottle has the better suds? Which bottle has the clearer water?

People do not like hard water for washing. More soap is needed to make suds. The cloudy material formed in the hard water makes a ring in the bath tub and it sticks to clothing and hair.

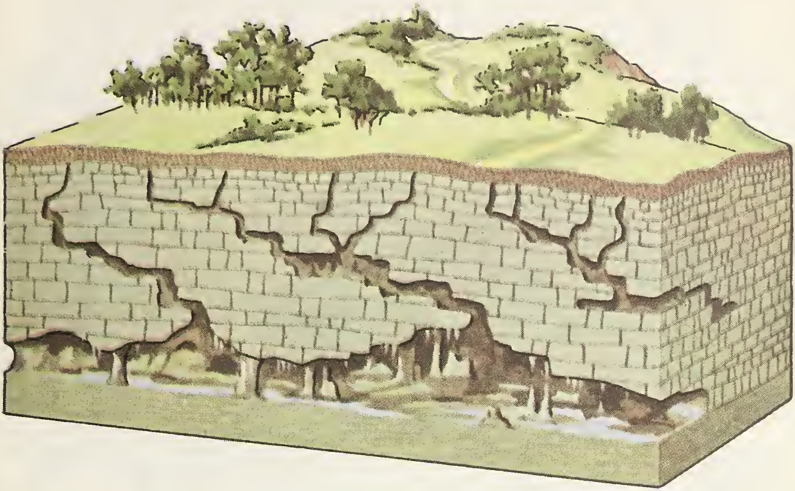


## Limestone Caves

Water that goes into the ground usually has weak acids in it. These acids help the water dissolve limestone.

Ground water may find cracks in the beds of limestone. It trickles through the cracks. As it flows through them, it dissolves the limestone and makes the cracks larger.

In the picture above, we see that ground water is beginning to flow through cracks in the limestone. It has already made some of the cracks larger.



This picture shows how the same limestone may look thousands of years later. Ground water has made some of the cracks much larger. These cracks have become caves.

People can go into these caves if they find openings big enough to crawl through. Sometimes there is an opening at the top where part of the roof of a cave falls in. Sometimes people can go into the opening where the water comes out.

Suppose that the water keeps flowing through the limestone for thousands of years longer. What do you think might happen to the cave?

When people go into a cave they may find the stream that made it. As long as the stream flows it will keep making the cave larger.

Sometimes rocks fall across the stream. The rocks dam up the water and make a lake. People often take boats into the cave and travel on the underground lake.

The streams in caves must come out somewhere. Usually they come out as big springs. Sometimes they come out beneath rivers and lakes.

The stream in a cave may find a new path through cracks in the limestone. Then the old opening will be dry. People can enter the cave through this opening if it is large enough.

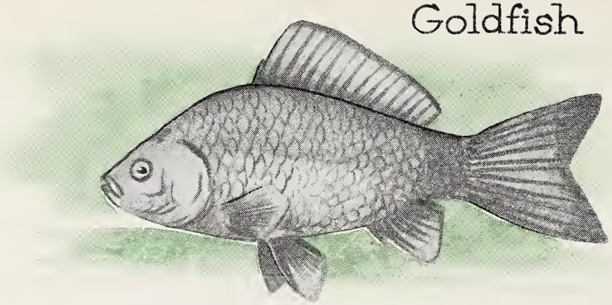
## Hot Springs and Geysers

In some parts of the world there are hot rocks deep under the soil. Ground water that trickles down to these rocks becomes hot. Sometimes this water comes out in hot springs. Sometimes it is blown upward by steam as geysers.

---

1. Why is it dangerous to drink water from springs that have not been tested?
2. Where does the water in a well come from?
3. What is hard water?
4. Why does the water level in the soil change through the year?
5. How can water make a cave?
6. How do plants get water in dry weather?
7. Why are dissolved minerals in ground water important to the farmer?

# Fish Life



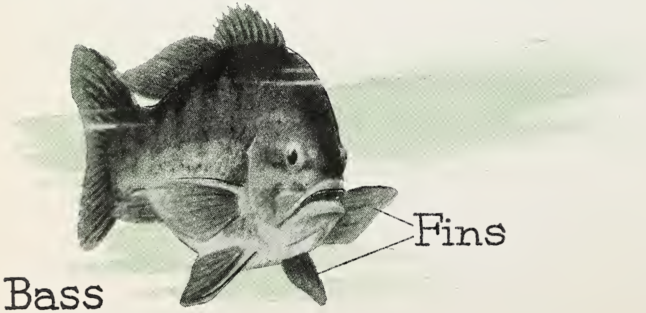
## How a Fish Swims

A goldfish can show you many things about the way most fish swim. Study the goldfish carefully. How many fins does it have? Where are the fins?

How does the goldfish drive itself forward rapidly? How does it balance itself when it is not moving ahead? Can a goldfish swim backward? If so, which fins does it use?

Some of the fins keep the fish moving in a straight line much as feathers keep an arrow moving straight. The fins on the back and the fin below the tail help to do this.

Look at pictures of different kinds of fish. Where are the fins on these fish?

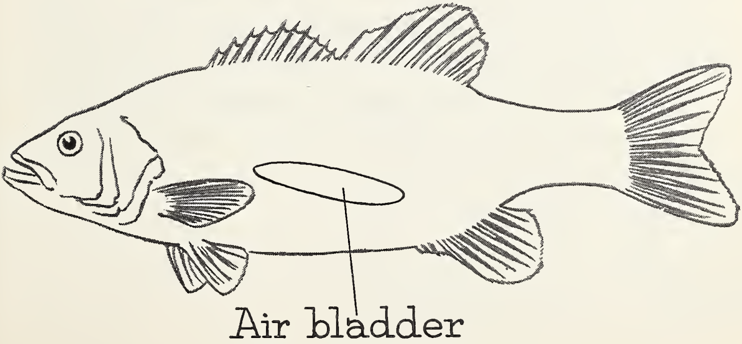


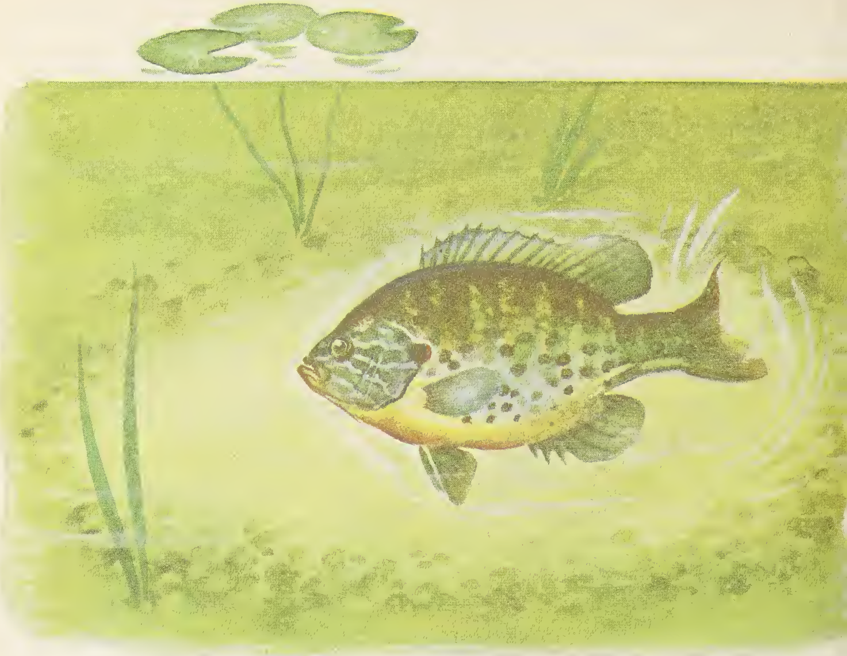
Does a goldfish rest on the bottom when it is quiet? Can the fish stay in one place without moving its fins? Does the fish begin to move up or down when it stops moving its fins?

Perhaps you have seen a dead goldfish. Does a dead goldfish float or sink?

Many kinds of fish have air bladders in their bodies. An air bladder is something like a balloon filled with air. It helps a fish float. The fish does not need to swim so hard to keep off the bottom.

A dead fish floats on its side because the air bladder is near the middle of the fish.





## The Life of a Sunfish

In spring the male sunfish begins to build a nest. He chooses a place in clear, shallow water, usually among water plants.

He waves his tail rapidly near the bottom. This washes away the mud. He picks up small stones with his mouth and carries them to the edge of the nest.

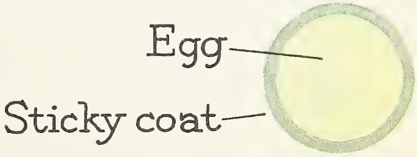
The finished nest is shaped like a saucer. It is about twice as wide as the sunfish is long. The bottom is made of clean, fine sand.

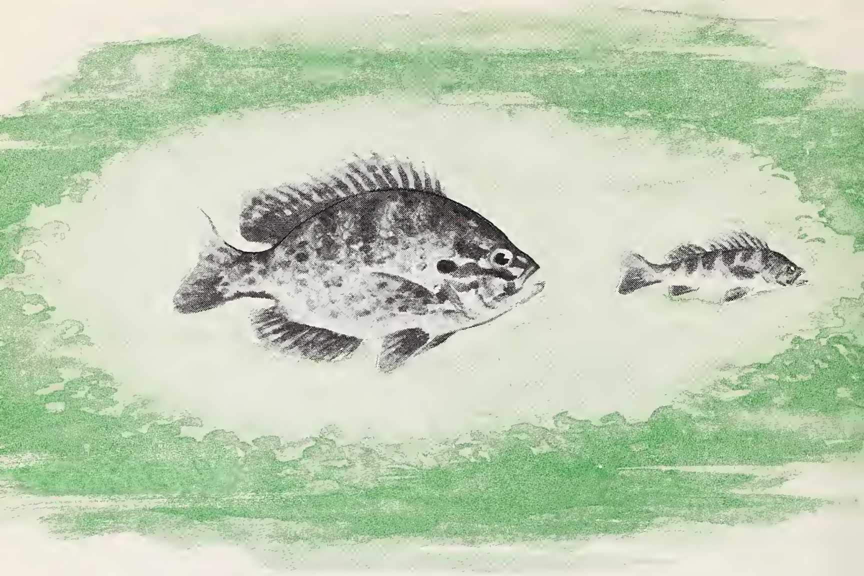
Soon a female sunfish swims into the nest. The two then swim around and around the nest. The female lays eggs. The male gives off sperms.

Then the female swims away. Sometimes other females come and lay their eggs in the nest also.

The eggs fall to the bottom. Each egg is sticky on the outside and it sticks to the sand in the nest.

The sperms fall too. They enter the eggs. Only after a sperm enters an egg can the egg develop.

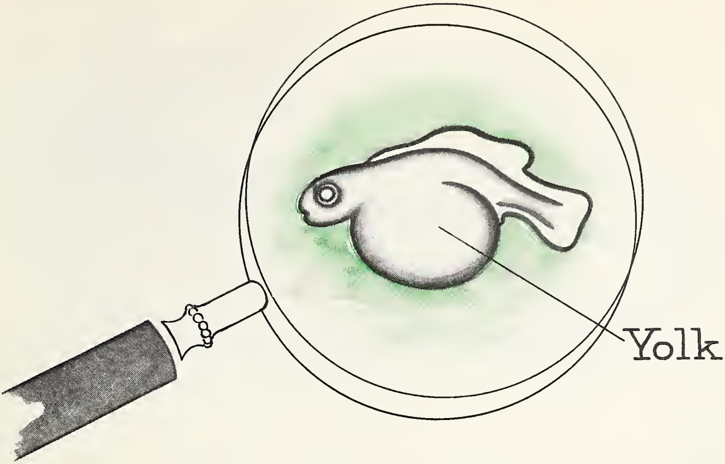




A female sunfish does not take care of her young. She swims away and leaves her eggs. The male stays and takes care of the nest.

Each male guards his nest carefully. He tries to chase away other water animals that might eat the eggs. He washes away mud that falls on the eggs.

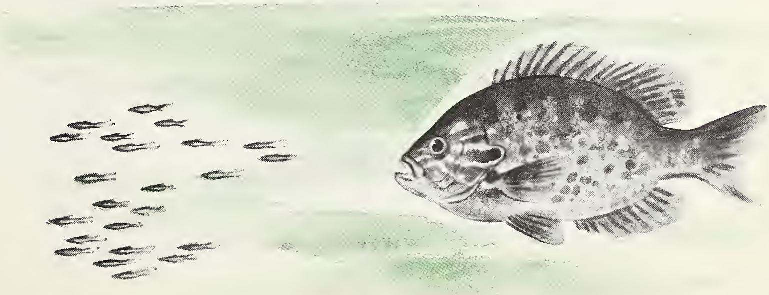
There are many dangers for the eggs. Most small water animals eat them. Salamanders, tadpoles, and almost all kinds of water insects must be kept away. Other fish, even other sunfish, will eat the eggs if the male does not guard the nest all the time.

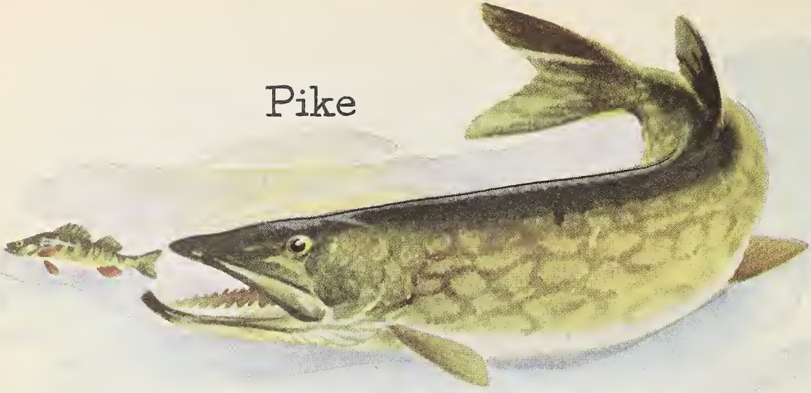


Sunfish eggs develop rapidly. After a week of warm weather, the young sunfish begin to move about. The male stops guarding them soon afterwards.

A young sunfish does not eat at first. It uses the food in the yolk of the egg from which it grew. When the yolk is used up, it begins to feed on very tiny plants and animals.

Young sunfish have many enemies. Many meat-eating animals hunt for them. Only a few live to grow up. These are the ones that have more young in later years.



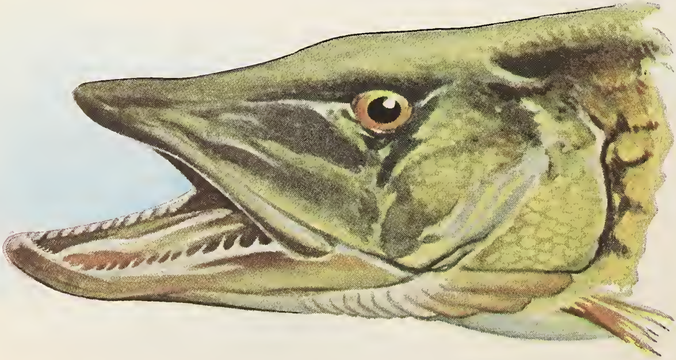

Pike

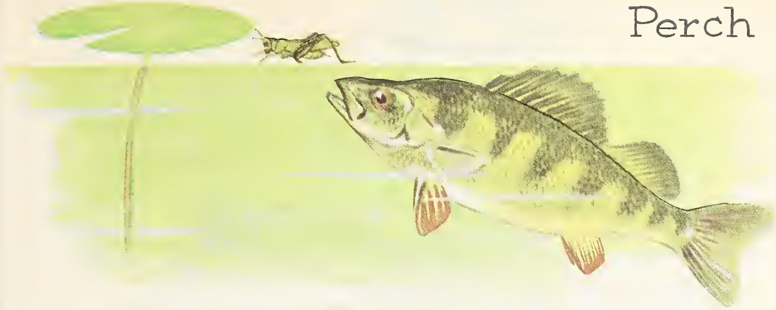
## How Fish Get Their Food

Most fish eat animals smaller than themselves. Many kinds eat other fish, even young fish of their own kind.

Fish that catch and eat other fish usually have large mouths. Some of them can swallow fish half as long as themselves.

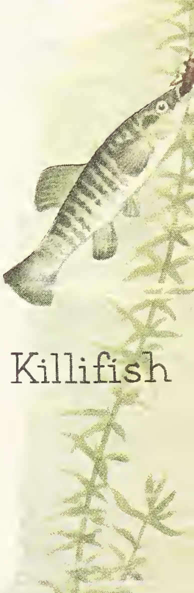
Such fish usually have sharp teeth. They use the teeth to hold the animals they catch. They do not chew with these teeth. They swallow their food whole.

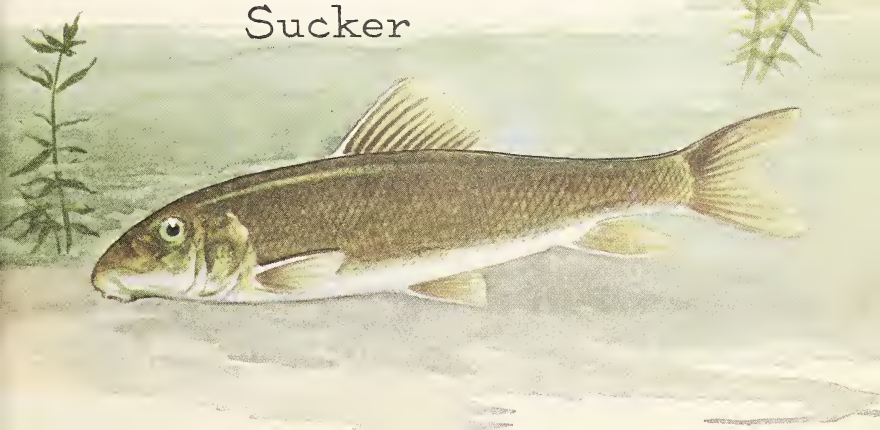


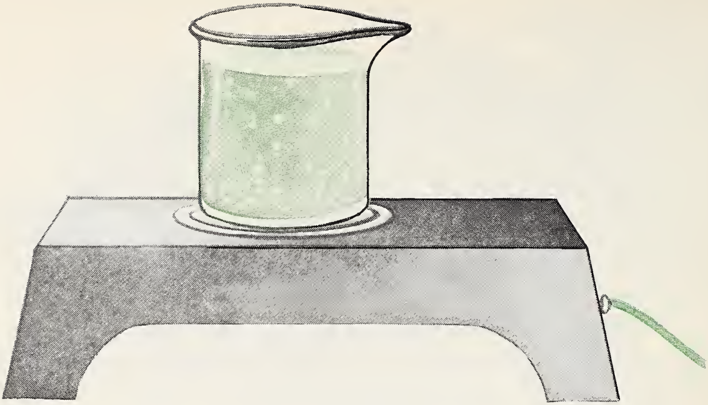


Many fish eat insects that are on water plants. They get these insects by sucking them in with a mouthful of water. These fish also eat insects that fall on top of the water. Such fish usually have their mouths on the front of their heads. How is this helpful to them?

Fish called suckers eat tiny plants and animals that live on the bottoms of ponds and streams. A sucker puts its mouth against the bottom and sucks in its food. Notice the shape of the sucker's mouth. Notice where the mouth is. How is this helpful to the sucker?





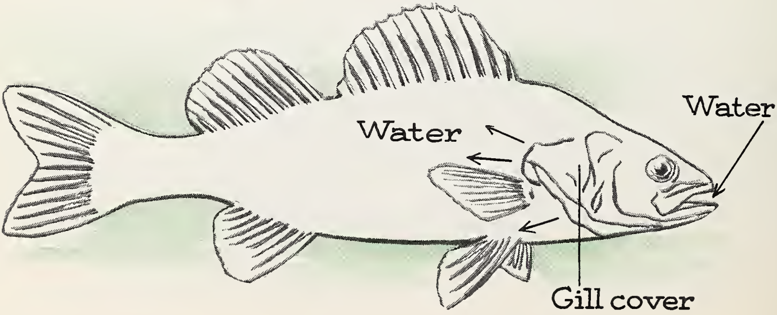


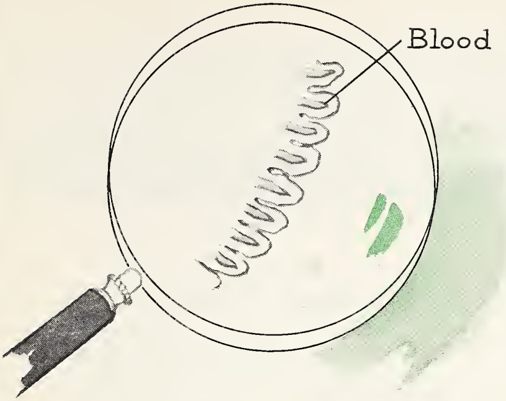
## Oxygen and Fish

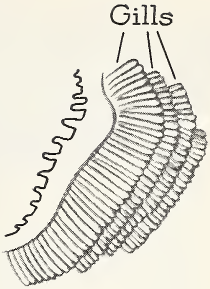
Oxygen is a gas that is important to all animals. They must have it so that they can use the energy in their foods.

Land animals get their oxygen from the air. Fish and many other water animals use oxygen that is dissolved in water.

Heating water drives out oxygen and other gases dissolved in it. Put some cold water in a glass cooking dish and heat it. In a few minutes you will see bubbles on the sides of the dish. These are bubbles of oxygen and other gases that are leaving the water.



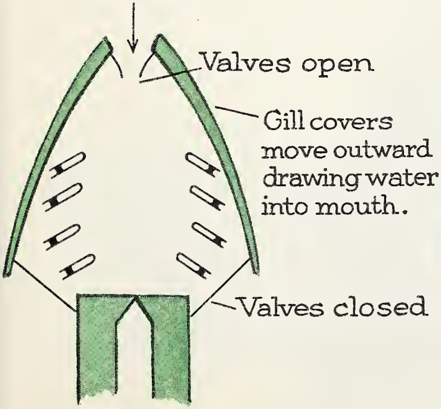


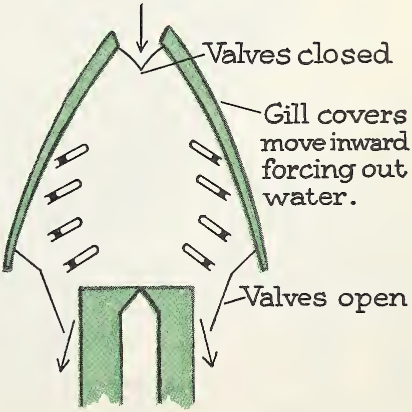


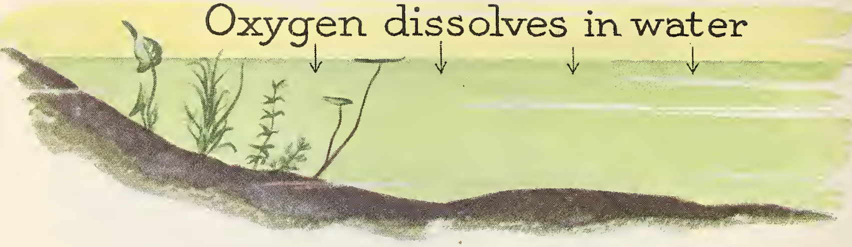
Fish take the oxygen from the water with their gills. The gills are in the back part of a fish's head under the gill covers.

The fish takes in fresh water through its mouth. This water passes around the gills and goes out slits behind the gill covers.

The skin on the gills is very thin and there is blood close to the surface. Oxygen is able to go from the water through this thin skin. The blood carries the oxygen to all parts of the fish's body.





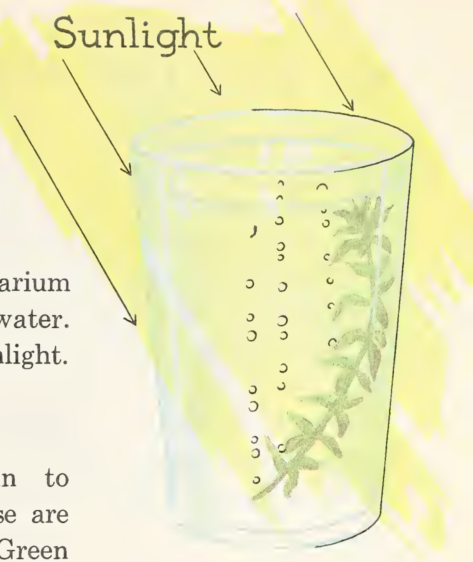


## How Oxygen Gets into the Water

Probably most of the oxygen in water comes from the oxygen in the air. This oxygen dissolves into the water at the top of a pond or a slow stream. Tests show that there is more oxygen in the upper part of a pond than at the bottom.

In swift streams, bubbles of air are carried under water. Some of the oxygen in the bubbles dissolves into the water. Swift streams usually have more oxygen than quiet streams and ponds.

How do waterfalls help add oxygen to the water?



Put some green aquarium plants in a glass jar of water. Set the jar in sunlight. Watch it closely.

Soon bubbles begin to leave the plant. These are bubbles of oxygen. Green plants give off oxygen when they are making sugar in sunlight.

The oxygen given off by green plants dissolves in the water. If there are many green plants in ponds or streams, part of the oxygen in the water comes from the plants while they are making food.

Oxygen from plants in sunlight

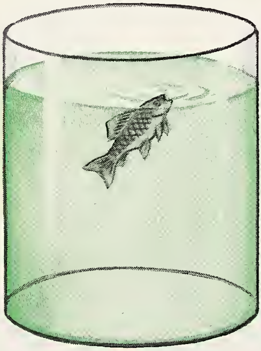
## How Water Loses Oxygen

You have already seen that heating water drives out the gases dissolved in it. Heating is an important reason for water losing its oxygen.

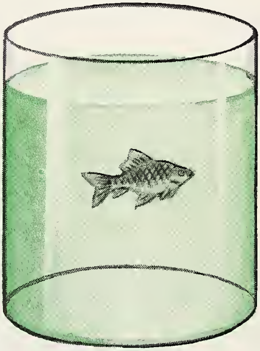
Heat some water until the gases have bubbled out. Then cool the water by letting it stand. Pour the water into a glass jar. Pour fresh, cold water into another jar of the same size. Then put a goldfish in each jar and watch closely.

In a few minutes the goldfish in the first jar will come to the top for water that has oxygen dissolved in it. There was not enough oxygen farther down. The other goldfish will have enough oxygen and will not need to come to the top.

Do not leave the goldfish in the first jar. The fish is uncomfortable there and it may even die.



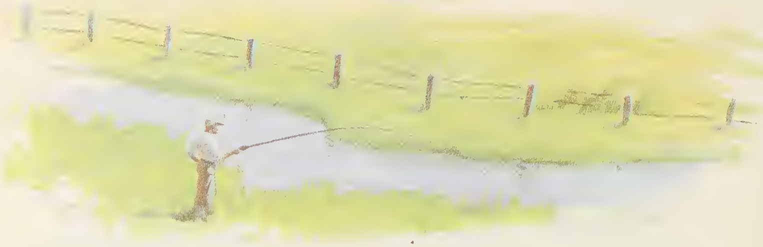
Water that has been heated and then cooled



Cool, fresh water

Animals that live in ponds and streams use some of the oxygen dissolved in the water. If there are many animals, they may use up most of it. Sometimes we put too many animals in one aquarium and then the animals die because there is not enough oxygen.

Some kinds of bacteria use oxygen from the water. The bacteria that causes dead things to decay are important because there may be so many of them. There may be countless millions of these bacteria in streams where sewage and garbage are dumped.

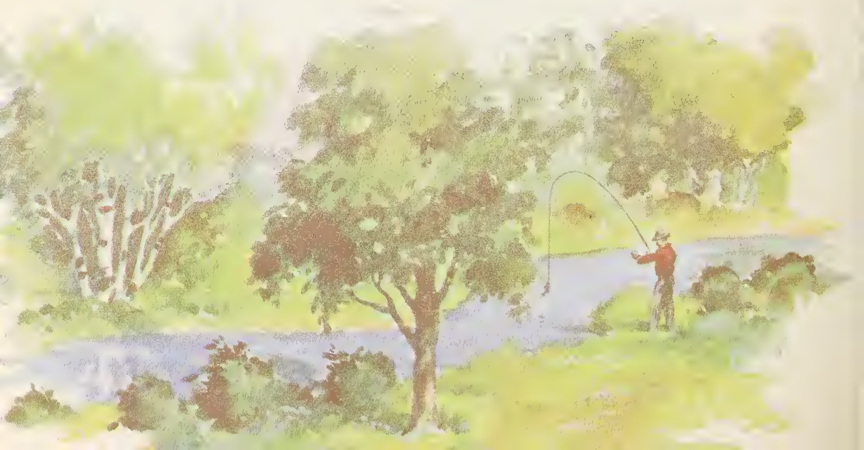


## Conservation of Fishing

Above is a picture of a stream that you might find in many places. All the trees and bushes have been cut down. Below is a picture of the same stream as it might look if trees and bushes were growing along its banks.

Which stream becomes warmer in summer? Which stream digs away its banks and becomes muddy? Which stream is better for fish? Give the reasons for your answers.

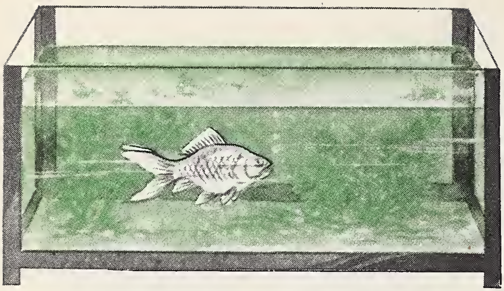
Sometimes people buy the land around the headwaters of good fishing streams. They plant trees and let the bushes grow. Tell how this helps. How are people other than fishermen helped by this?

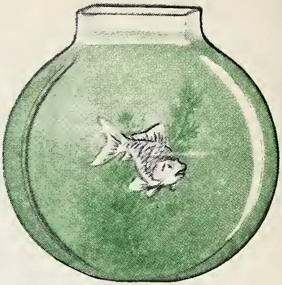


Here are two ways that fishing can be spoiled. A city may dump its garbage into the river. It may also run its sewer into the river. Why is this bad for animals that live in the river? What are some other reasons people should not do this?

Most provinces have special departments that try to protect the streams. They try to keep cities from dumping garbage and sewage in the streams. They try to keep factories from dumping chemicals into the streams. They try to keep sawmills from dumping sawdust in the streams.

Has your province a conservation department? Find out what it does to protect the streams in your province.

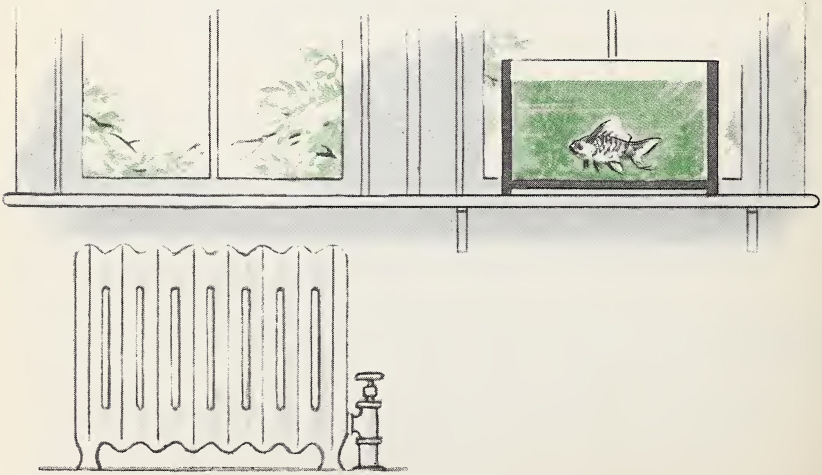


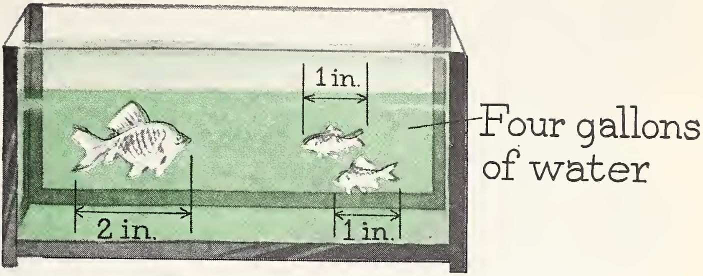


## Oxygen in Aquariums

Here are two kinds of aquariums. In which one does more of the water touch the air? In which one will oxygen dissolve faster?

There may be several places where you can keep an aquarium. One place might be above a radiator. Another place might be in a sunny window. Another might be in a window that faces north. Which place do you think is best for an aquarium?

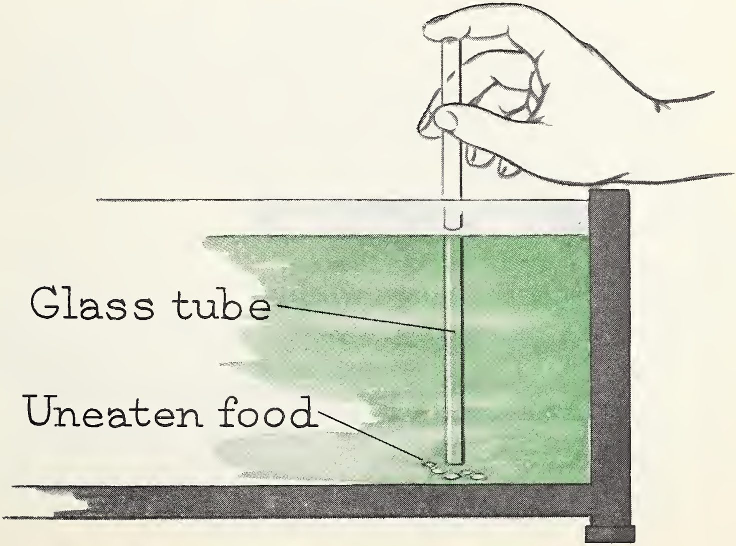



1 in.
Four gallons of water
2 in.
1 in.

Each fish should have enough water so it will be sure of having oxygen. A good rule is to use a gallon of water for each fish an inch long, two gallons of water for each fish two inches long, and so on.

Always take out dead plants and animals and uneaten food as soon as possible. Why?

Here is a way to take uneaten food from an aquarium. Hold a glass tube as shown and lower it to the bottom. Take your finger from the top. Water and uneaten food will enter the tube. Then put your finger back on the tube and lift it from the water.



## Brook Trout

Brook trout are fish that need much oxygen. They can live only in cold lakes and swift, cool streams.

Why is it that brook trout cannot live in warm ponds and streams? Why do they die when sewage and garbage are dumped into the streams where they live?

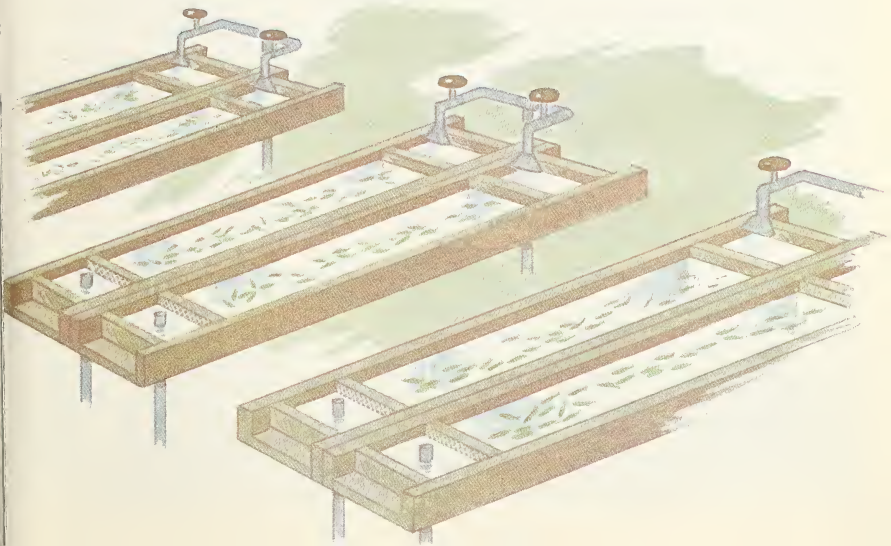
Brook trout lay their eggs in late fall. They swim up cold streams as far as they can. They make nests somewhat as sunfish do. The females lay their eggs. The males give off sperms. Then the trout cover the eggs with gravel. The males may guard the nests for a few days before they leave them.

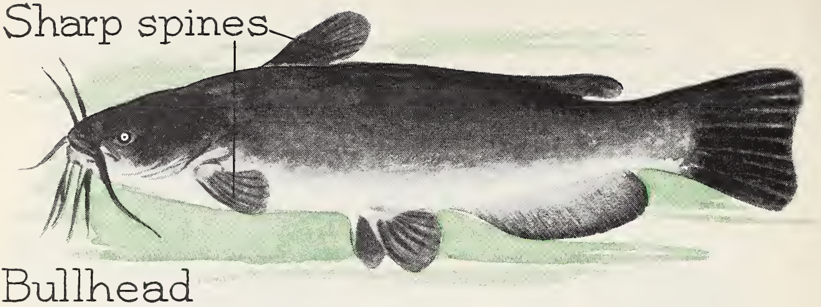
Fishermen like to catch trout, but so many streams have been spoiled for fishing that there are not enough trout for all the fishermen.

Special departments in some provinces have built fish hatcheries to raise young trout.

Full grown trout are kept in pools of cold running water. During the egg-laying season, men squeeze eggs from the females and sperms from the males. The eggs and sperms are mixed in pails.

Then the eggs are put in trays of cold running water. After the eggs hatch, the young fish are fed carefully until they are three or four inches long. Then they are put in cold streams and lakes.





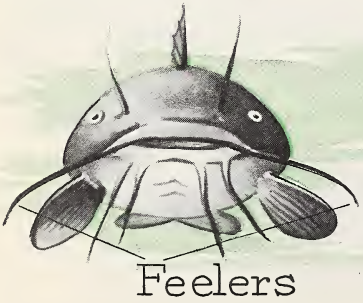
## Bullheads

Bullheads need less oxygen than many other kinds of fish. They can live on the bottoms of warm, muddy ponds.

Different kinds of bullheads have many names. Sometimes they are called "horned pout," "mud cats," and "catfish."

Bullheads usually lie on the bottom of a pond. Their eyes are small. Perhaps they do not need large eyes in muddy water. They have four pairs of "feelers" that look like cats' whiskers. The feelers seem to be used in finding food in the mud.

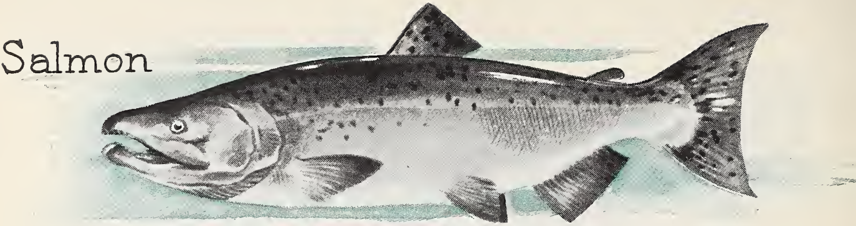
Bullheads also have sharp spines in three of the fins. Fishermen should know how to pick up bullheads so that they do not hurt their hands.



The male and the female bullhead build the nest together. They move pebbles and bits of sticks from the nest. They wash away some of the mud. The finished nest looks a little like the nest of the sunfish.

The female lays her eggs and the male gives off sperms. Then the male guards the nest. When the eggs hatch, the male guards the young bullheads for several days.

Most kinds of bullheads are small, but there are kinds that grow large. The catfish in the Mississippi sometimes weigh more than 100 pounds.



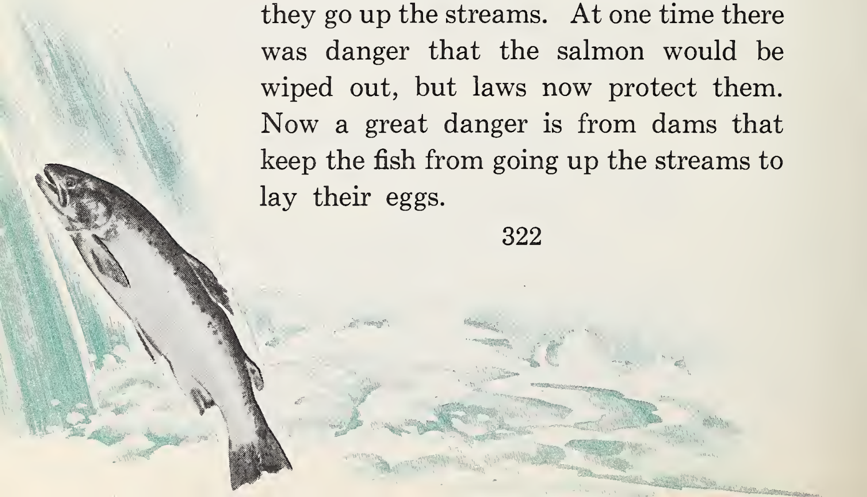
## Fish That Migrate

A number of fish migrate into shallow streams to lay their eggs just as brook trout do. One of the most important of these is the salmon of the Pacific Coast. These salmon live in the ocean most of their lives. In the fall, when they are full grown, the salmon swim up the rivers. They may go up for hundreds of miles.

They lay their eggs and give off sperms in shallow water near the upper ends of the streams. Then they die.

The young fish live in the streams until they are a few inches long. Then they swim to the ocean. When they are full grown they swim back up the same streams they came down.

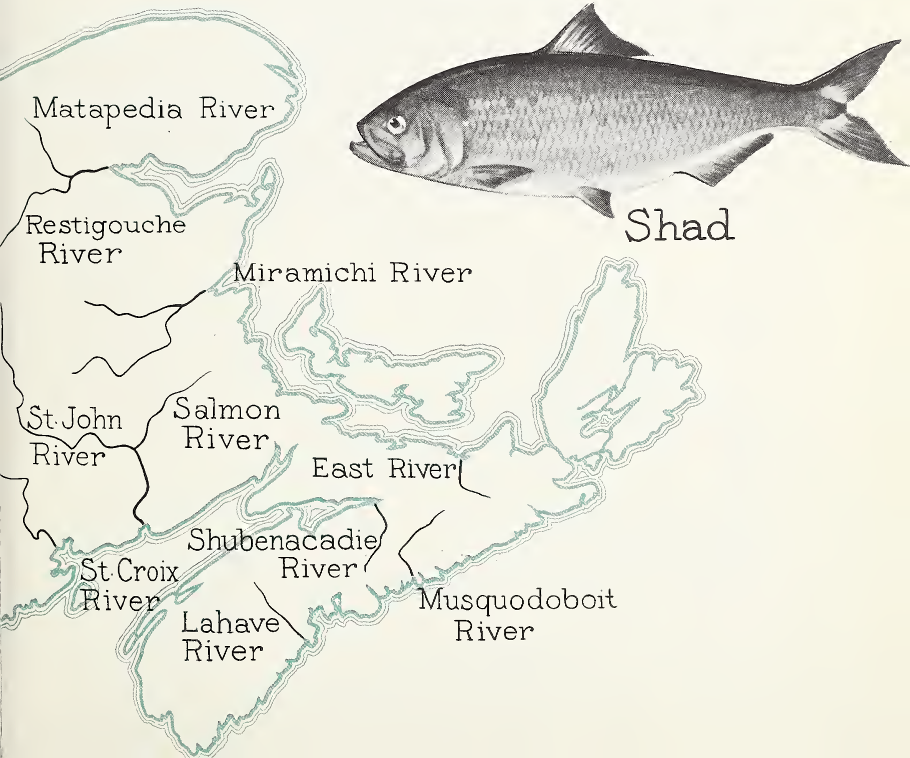
Salmon are caught in great numbers as they go up the streams. At one time there was danger that the salmon would be wiped out, but laws now protect them. Now a great danger is from dams that keep the fish from going up the streams to lay their eggs.



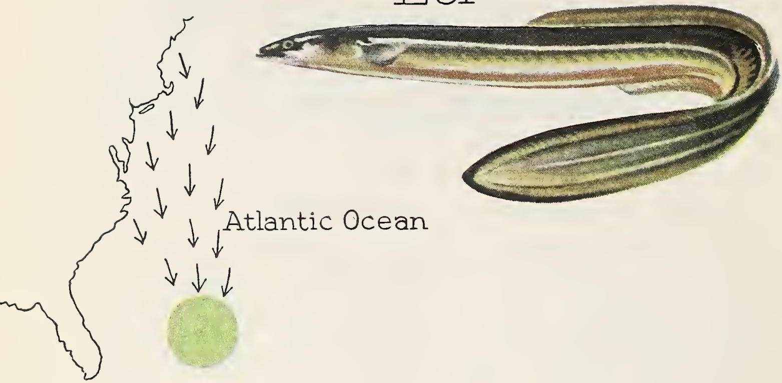
A different kind of salmon lives on the Atlantic Coast. These fish do not die when they lay their eggs. They swim back to the ocean again.

Most of the rivers in the United States are no longer fit for the Atlantic salmon because of sewage, chemicals from factories, and dams across the rivers. There are still some good rivers for them in Canada.

The shad is another fish that migrates up the rivers of the Atlantic Coast. Shad spend most of their lives in the Atlantic Ocean. They go up the rivers in spring to lay their eggs. There were once many more shad than there are now. Many rivers have become too dirty for shad.



# Eel



Eels look a little like snakes but they are really fish. Eels have fins and gills like other fish.

Eels migrate, but much differently from the fish you have been studying. Eels live near the headwaters of streams most of their lives. When they are full grown they migrate to the ocean to lay their eggs. The young eels then swim back up the streams.

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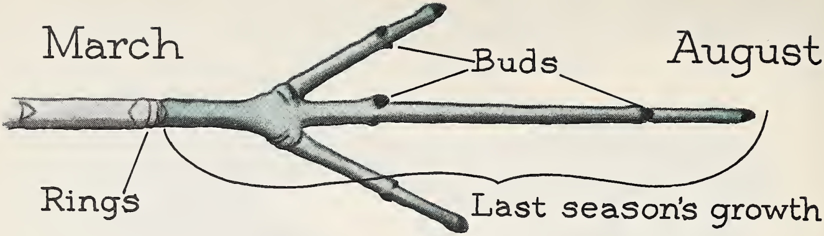
1. What do most fresh water fish eat?
2. What must happen to a fish egg before it can develop?
3. How does oxygen get into water?
4. How does a fish get the oxygen it needs?
5. Why does garbage and sewage spoil fishing?
6. Where is the best place in a house to keep an aquarium?

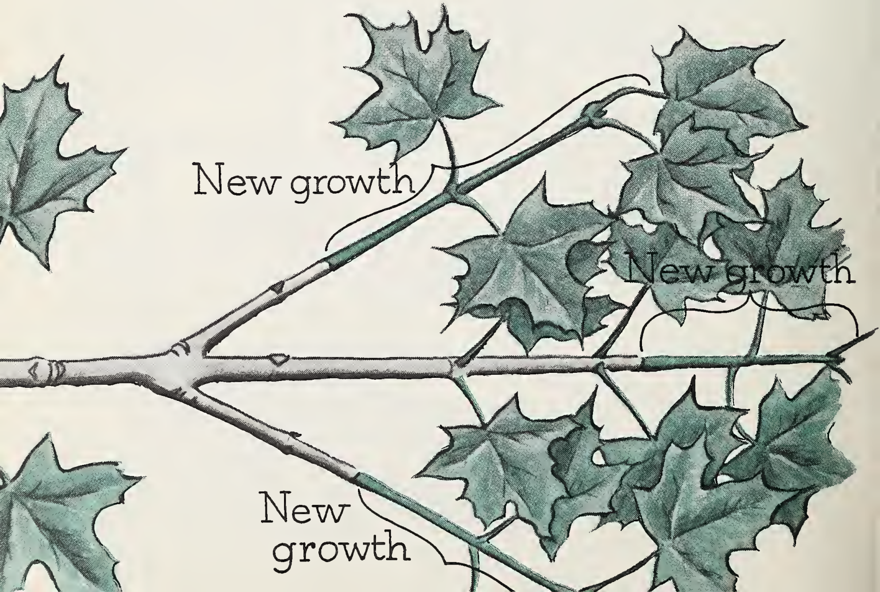
# Trees



## How a Tree Grows

Look at a twig from any small tree. Notice that the end of the twig is a lighter colour than the rest of the twig. It is often light green. This is the part of the twig that grew during the last growing season. There are often rings that show where each season's growth ended.

One twig may grow only a few inches during a season. But if you could add together the growth of all the twigs on one tree, you would find that the tree grew many feet each season.

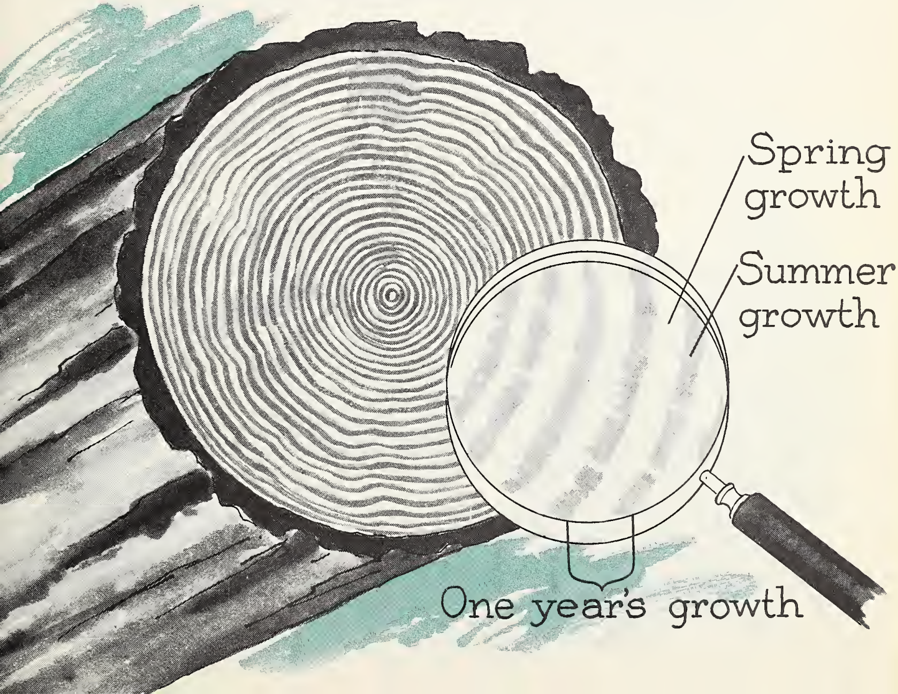


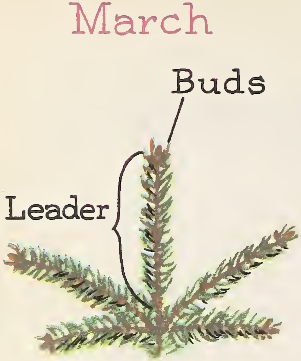
The trunk and twigs of a tree not only grow longer but they also grow bigger around. Each year, a tree adds a layer of wood beneath its bark.

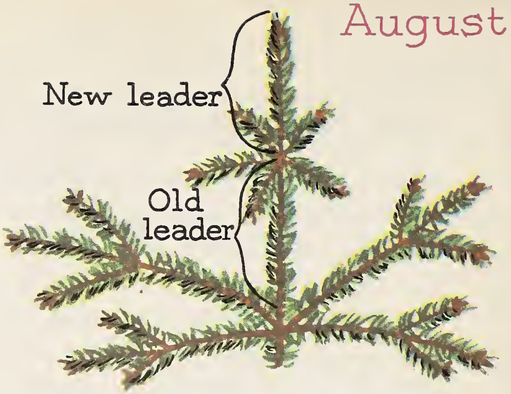
Peel the bark from a live twig. Notice the green layer beneath the bark. This is where the tree is growing bigger around. Wood is made in this layer during the spring and summer.

If you cut through a tree trunk or large limb, you will see rings in the wood. These rings are the layers of wood that are added each year. The light-coloured layer was made in the spring when the tree grew rapidly. The hard, dark ring was made when the tree grew more slowly during the summer.

You can find out how old a tree is by counting the rings in the trunk. How old is the tree shown below?

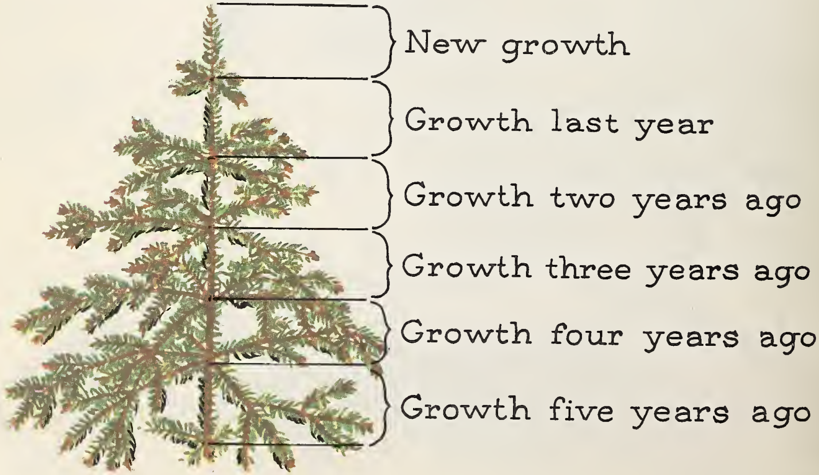




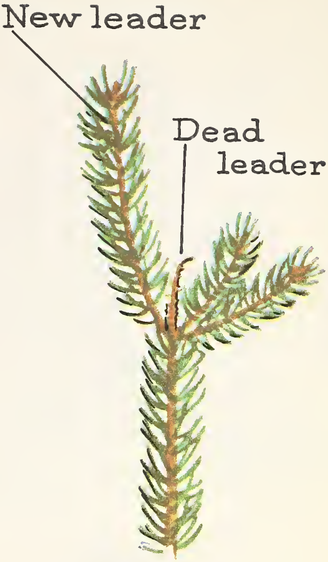


Most evergreens have a main stem or trunk from which the branches grow outward. Healthy evergreens have a spike-like top which is called the leader. It is so called because each spring and summer this part of the tree leads the others in growing upwards. During the summer new buds will form at the top of the leader. The top bud will grow into a leader during the next growing season. The other buds will grow into side branches.

You can often tell the age of young pine trees or spruce trees by counting the spaces between branches on the trunk of each tree. Each space represents one of the leaders in past years.



The leader of one of these trees may be killed by freezing, by insects that lay their eggs in the buds, or by animals that eat the buds. Then a side stem usually turns upward and becomes a new leader. For a few years there will be a bend in the trunk where the side branch turned upward. In time, however, the trunk grows large and the bend disappears.



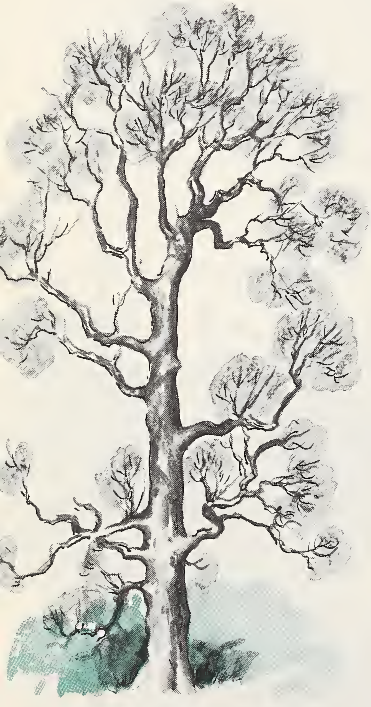
Sometimes two or more side branches turn upward. Then there is more than one leader. Look for evergreen trees that have more than one leader. Why are such trees worth little for lumber?

## The Shapes of Trees

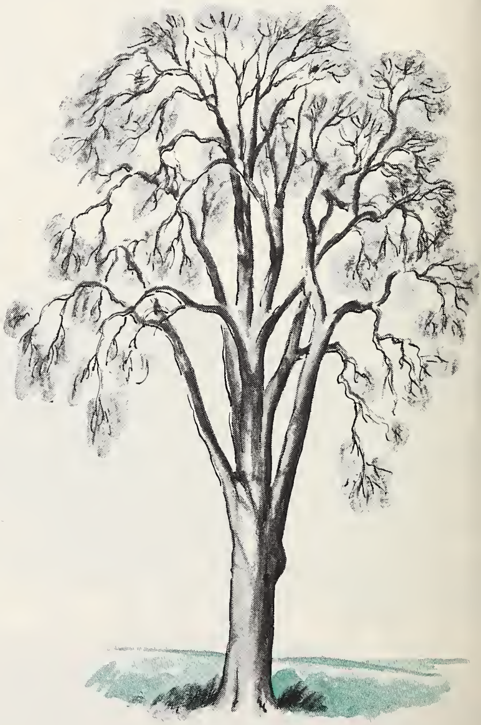
The shape of a tree depends upon how many of its twigs grow upward. Some kinds send up one main twig. A tree of this type has a trunk that rises through the centre of the tree almost to the top.

Other kinds of trees send several twigs upward. A tree of this type has a short trunk that divides into many branches.

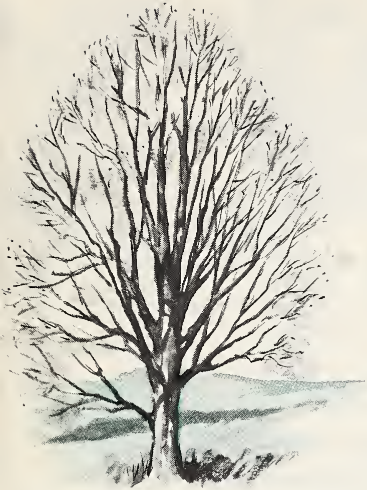
Look at trees growing near your school. Find trees of each type. Try to learn their names.



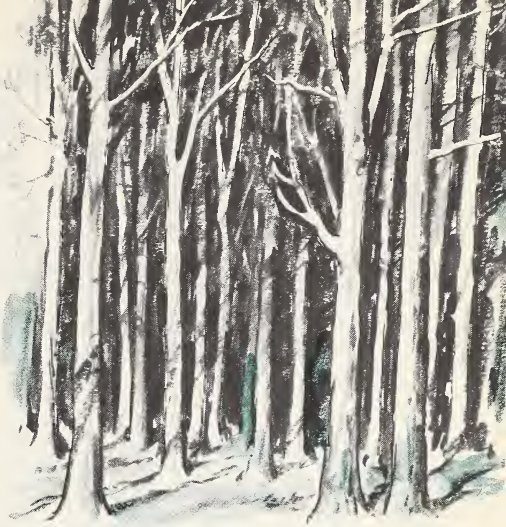
Oak



Elm



Maple tree in a field



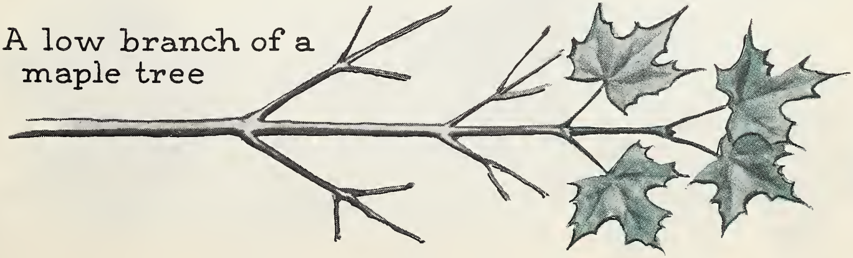
Maple trees in a thick woods

The shape of a tree also depends upon whether it is growing in the open or in a thick woods. Above are pictures of maple trees. The tree growing in the open has light coming from all sides. Each twig grows longer and larger. Notice the shape of the tree.

The trees growing in the woods have plenty of light only at the top. The lower twigs die. The upper branches grow upward. Notice the shape of these trees. Which trees will make better lumber?

Look at twigs that are shaded by other twigs. Are some of them dead? Are some of them dying?

A low branch of a maple tree

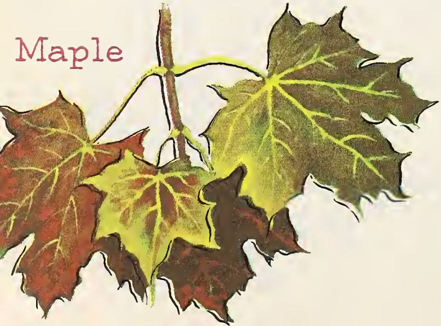


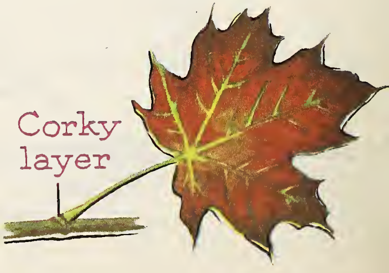
## The Leaves of Trees

The leaves of trees have many shapes. Some are almost round. Some have edges like saw teeth. Some are divided into several smaller parts. Some are shaped like needles. You can tell one kind of tree from another by the leaves.

Tree leaves make the food that the trees need. They make it from water, minerals from the soil, and air. They use energy from sunlight.

Many kinds of trees lose their leaves at the end of the growing season. A corky layer grows at the end of each leaf stalk. Water stops rising into the leaf and the leaf dies. The colour often changes to red, orange, yellow, or brown. Then the leaf falls off.

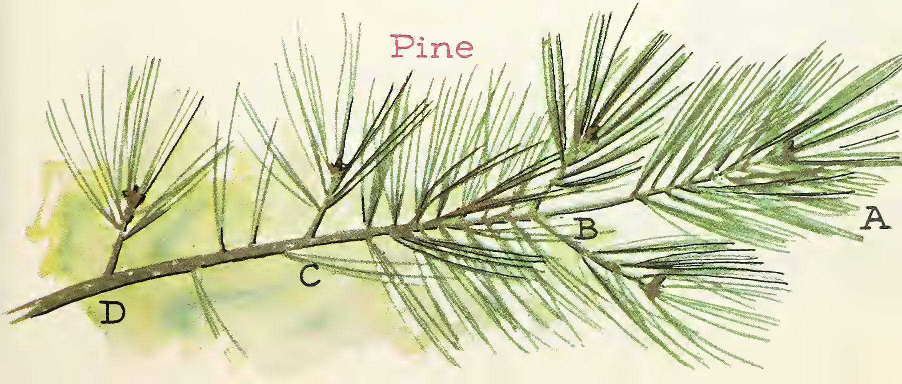


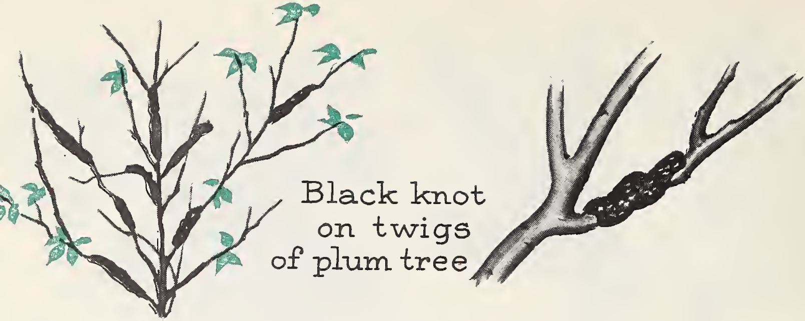


Other kinds of trees keep their leaves through the winter. These trees are called evergreens. Look for evergreen trees and learn their names.

Evergreens, such as pines and spruces, have leaves like needles. Others, such as cedars, have leaves shaped like scales. The seeds of these trees grow in cones.

Most of the cone-bearing trees keep their leaves several years. The pine twig shown below has needles that grew in three different seasons. The new needles are on the newest growth between B and A. Last season's needles are still on the twig that grew between C and B. The needles that grew two seasons ago are falling from the twig between D and C. All the needles have fallen from the twig that grew three seasons ago.





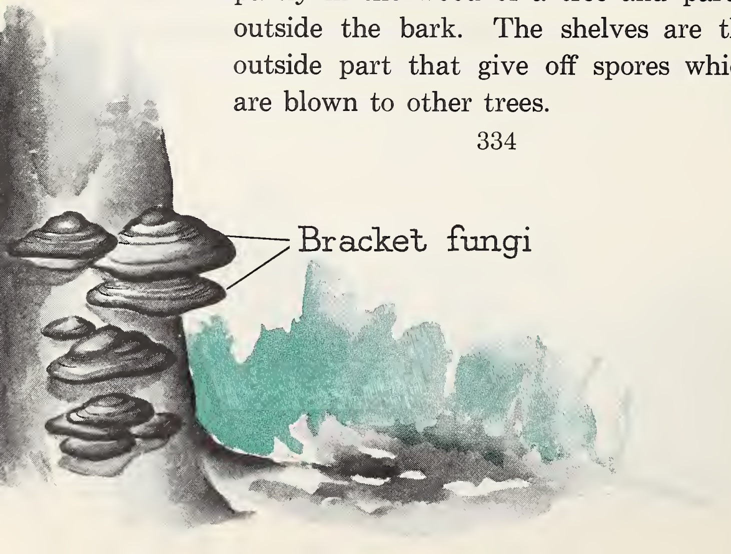
Black knot on twigs of plum tree

## Enemies of Trees

Among the many enemies of trees are some plants that live inside the trees. These plants are called **parasites.** They use the tree for food. Usually they harm the trees, and sometimes they kill the trees.

Perhaps you have seen black growths on plum trees. These are parts of small plants living inside the twigs. The black parts give off spores that are carried by the wind to other plum trees.

A bracket fungus is a parasite that grows partly in the wood of a tree and partly outside the bark. The shelves are the outside part that give off spores which are blown to other trees.

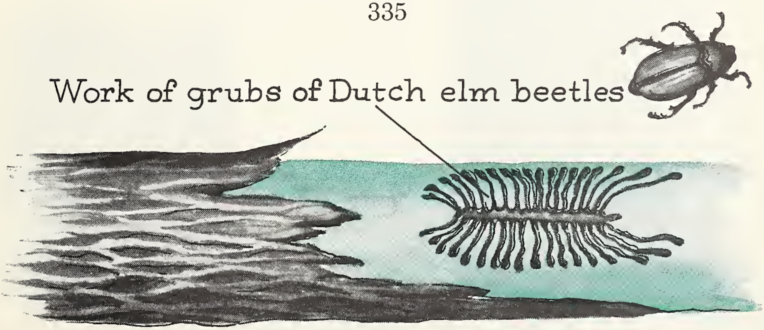


Dead chestnut trees

Fifty years ago the trees in this picture were healthy chestnut trees. Chestnuts were one of this country's favourite nuts. Chestnut lumber was used for many things.

Nearly all of these chestnut trees have been killed by tiny parasites. The parasites were brought in from Asia where they grew on another kind of chestnut tree. They killed the growing layer under the bark of our chestnut trees.

There are many other kinds of parasites that kill trees. Some of these parasites are carried by the wind from one tree to another. Other parasites are carried by insects. Elm trees are being killed by parasites carried by beetles that burrow under the bark of the trees.



Work of grubs of Dutch elm beetles

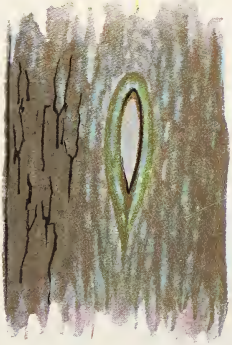
After a wind storm

## Tree Injuries

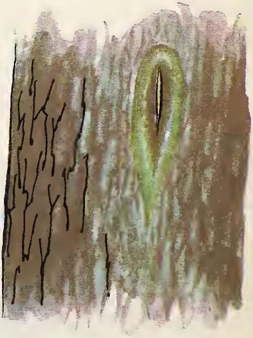
Trees are easily injured. Strong winds may tear off some of the branches. People may knock off some of the bark or cut the bark with knives and axes. How else may trees be injured?

A tree can heal a small injury in a few years. The growing layer under the bark spreads out over the injury. It makes new wood and new bark. In a few years only a scar remains.

Look for scars on trees to see how the tree heals small injuries.



Two years later

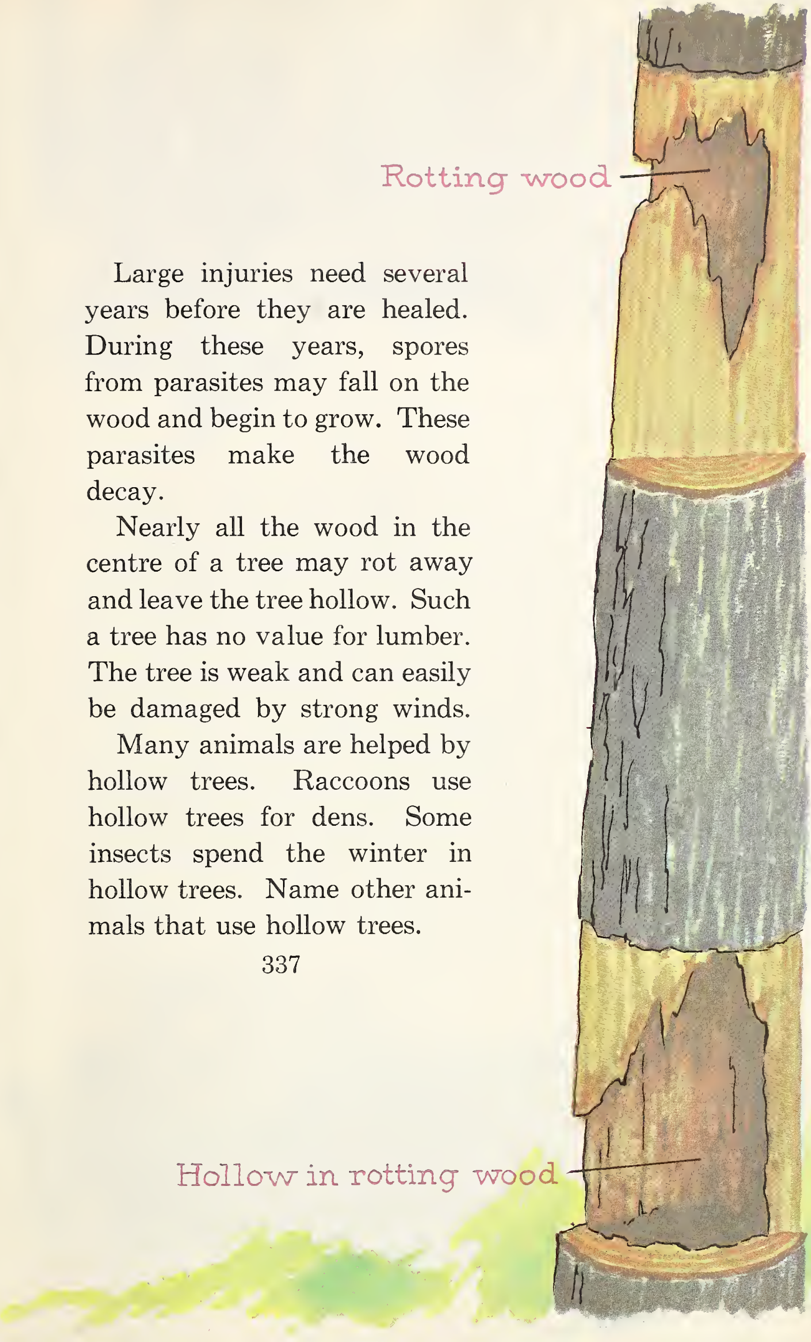


Five years later

Large injuries need several years before they are healed. During these years, spores from parasites may fall on the wood and begin to grow. These parasites make the wood decay.

Nearly all the wood in the centre of a tree may rot away and leave the tree hollow. Such a tree has no value for lumber. The tree is weak and can easily be damaged by strong winds.

Many animals are helped by hollow trees. Raccoons use hollow trees for dens. Some insects spend the winter in hollow trees. Name other animals that use hollow trees.



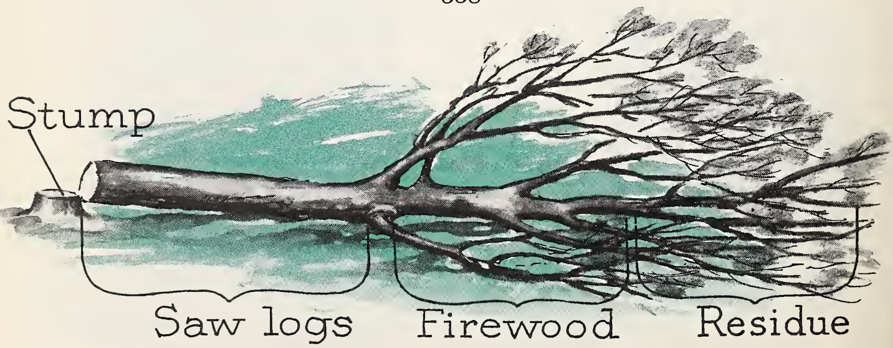
## Lumber

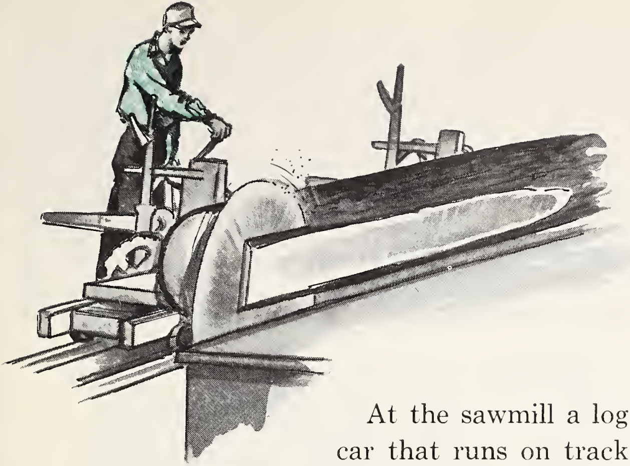
Lumber is one of our most important building materials. List some ways that lumber is used.

The best lumber comes from straight, tall trees. Hollow trees, crooked trees, and small trees do not make good lumber.

The good trees are cut down and sawed into logs. The logs are then taken to the sawmills.

At first the parts of the tree not used for lumber were left to rot in the forest or were burned at the sawmill. Today less wood is being wasted in this way as more of it is being made into furniture, pulp, paper, fibre board, rayon, celluloid and other wood products.

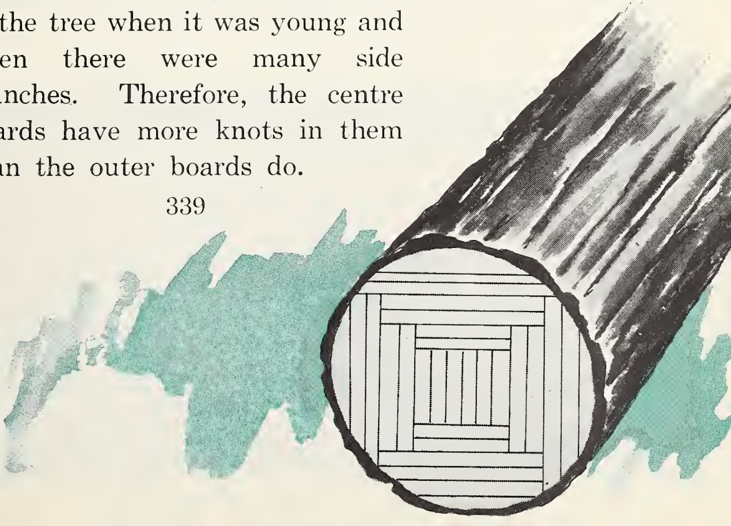




At the sawmill a log is put on a car that runs on tracks. The car pushes the log against the saw.

The boards cut from the outside of a log have bark on them. Such boards are usually used for firewood. After the outside boards are sawed off, a few more boards are cut from each side of the log. The picture below shows the order in which they are usually cut.

The centre boards are usually worth less than the outer boards. The centre of the log was the trunk of the tree when it was young and when there were many side branches. Therefore, the centre boards have more knots in them than the outer boards do.

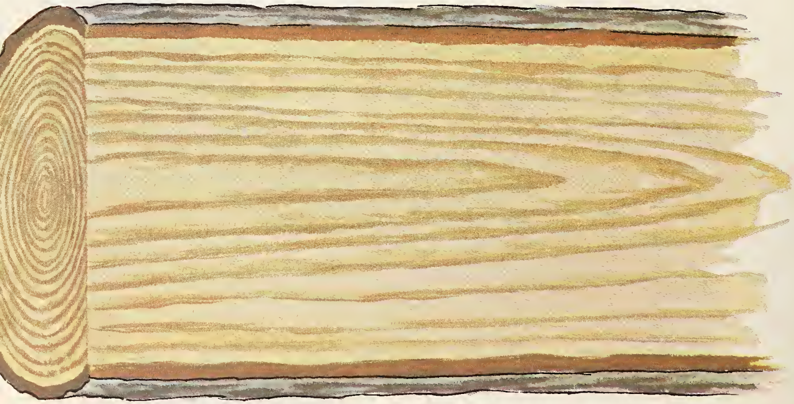


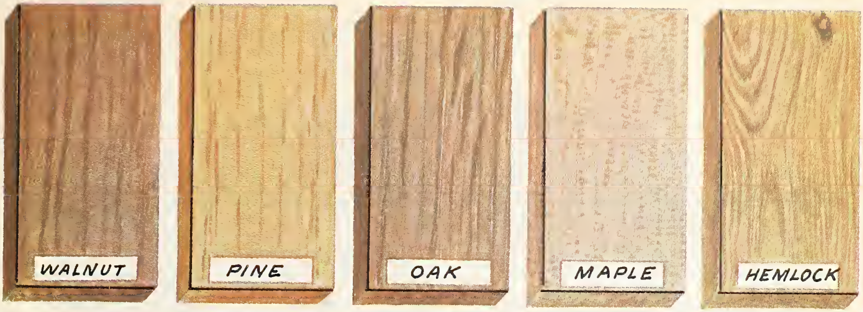
## Grain in Lumber

Look at boards in tables and other woodwork. Notice the pattern of light and dark wood. This pattern is called the grain of the wood. Can you find any boards that have no grain?

The grain is caused by sawing through the growth rings of a log. Imagine that you can see a log after one board has been sawed from it as in the picture below. Notice the growth rings in the end of the log and follow some of them along the side where the board was taken off.

Look at the growth rings in the end of a board. Follow some of them along the side of the board.

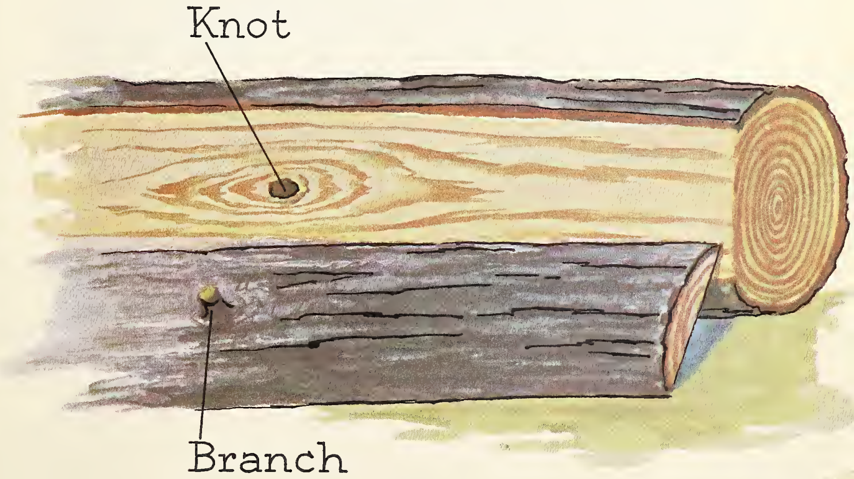




Different kinds of wood have different kinds of grain. Visit a lumber yard or a woodworking shop and study the different kinds of wood. Notice how the grain in each kind looks.

Collect small pieces of different kinds of wood. Smooth one side of each piece with sandpaper to make the grain show better. Label your collection.

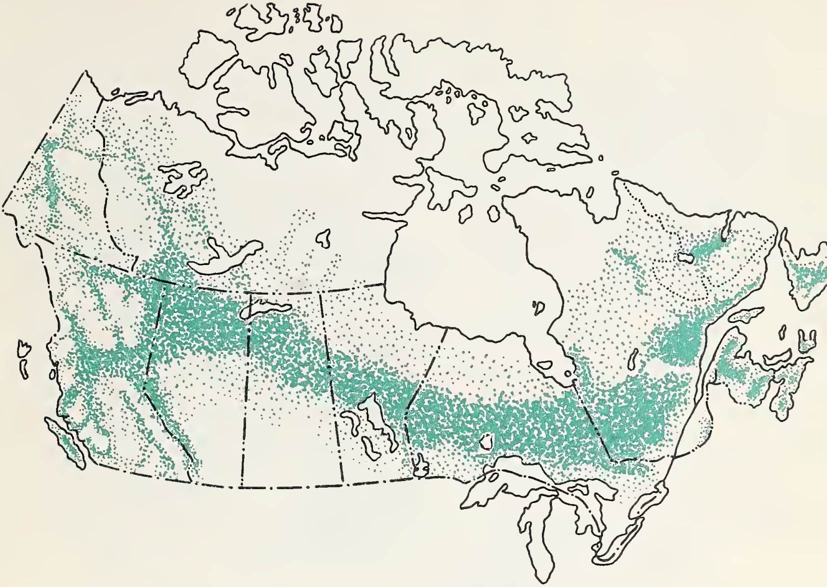
You may find dark spots called knots in some of your boards. Notice the grain around a knot. A knot marks the place where there was a branch on a tree. The picture helps you understand why a knot shows when a board is sawed from the tree trunk.



## Forests in Canada

When people from Europe first came to this country, they found great forests of large, straight trees. They often had to cut trees to make places for their houses. They had to clear fields for crops. They sometimes piled up the trees and burned them just to get rid of them.

Until about fifty years ago there were still great forests in the east except in good farming land. The forests of British Columbia had hardly been touched until that time. It seemed as though there would always be plenty of lumber.



Today the picture is different. The great white pines of our eastern forests are almost gone. Much of the big saw timber left is of poor quality. In the west there are still some stands of large trees but these are becoming fewer and smaller as time goes on.

Though our trees are now smaller, our foresters assure us that with proper management our forests can continue to supply us with enough wood for our needs.

Ninety per cent of the forest lands are owned by the people. The provincial governments administer the forests. A province may grant permission for lumber, pulp and paper, and other companies, and private individuals to cut timber on Crown lands. A small charge is made for the timber. The land remains provincial property.

## Destruction and Conservation of Forests

Forests have four main enemies: fires, insects, diseases and man. Fires may be started by lightning or man. Most of them are started by careless people who fail to put out their campfires, cigarette butts or matches. Insects kill many of our trees each year. Trees get diseases which may kill them. Man may cut too many trees that are not full grown.

We must all learn to care for our forests. We must protect them from fire and from wasteful cutting practices if we are to meet the increasing demand for wood.

Our federal and provincial governments are trying to show how trees can be used more wisely. They try to prevent forest fires. They study tree parasites to find out how to control them. They experiment with better ways to cut and use trees.

Our governments are also setting aside forests that should not be cut because the trees help hold soil and water on the mountains. Find out what your provincial government is doing to conserve its forests.

## How to Plant a Tree

Dig a hole that is a foot deeper and a foot wider than the roots of the tree. Loosen the soil in the bottom of the hole and put in some well rotted leaves or manure.

Set the tree in the hole. The roots should be at the same level as they were before the tree was dug up. Put some soil around the roots to hold them and fill the hole with water. Then put in the rest of the soil and pack it tightly with your feet. Keep the tree well watered.

---

1. How does a tree grow larger?
2. What makes the grain in wood?
3. Why are leaves important to trees?
4. Why are trees important to us?
5. Why are our good forests disappearing?
6. How can you help prevent forest fires?
7. What is being done to conserve our forests?

## The Major Topics Presented in Each Unit

* **Unit 1 — Plants That Are Not Green.** How non-green plants get their food. How non-green plants reproduce. How non-green plants do both good and harm.

**Unit 2 — Saving the Soil.** Why topsoil is important. How topsoil is being lost. How topsoil can be protected and restored.

* **Unit 3 — Time and Seasons.** How time is determined. What causes change of seasons. How seasonal changes affect living things.

* **Unit 4 — Our Eyes.** How our eyes are protected from injuries. How to take care of our eyes. How we see. How the eyes of animals compare with ours.

**Unit 5 — Making Work Easier.** Some common ways of doing work more easily. How some common tools work. How friction can be reduced.

**Unit 6 — Musical Sounds.** How musical sounds are produced. Some common musical instruments. How people make and hear sounds.

* **Unit 7 — Some Common Acids.** Acids in our daily lives. How to test for acids. How acids affect the things about us.

**Unit 8 — Electromagnets.** What electromagnets are. How electromagnetism can be changed. How electromagnets are used.

**Unit 9 — Bird Study.** What birds are like. How birds differ. How birds take care of their young.

**Unit 10 — How Airplanes Fly.** How airplanes are controlled. The forces that act on an airplane. How airplanes are given energy to fly.

* **Unit 11 — Warm Air in Motion.** What happens when air is heated. Causes of the unequal heating of air. Effects of air currents.

* **Unit 12 — Water in the Ground.** What happens to the water that goes into the soil. What wells and springs are. What ground water does to the rocks it flows through.

**Unit 13 — Fish Life.** How fish are adapted for a life in water. How fish reproduce. What factors harm fish.

**Unit 14 — Trees.** How trees grow. How trees are injured. How lumber is produced. How we can protect our forests.

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* These units include health and safety material.

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